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MACHINE DESIGN

June 1942

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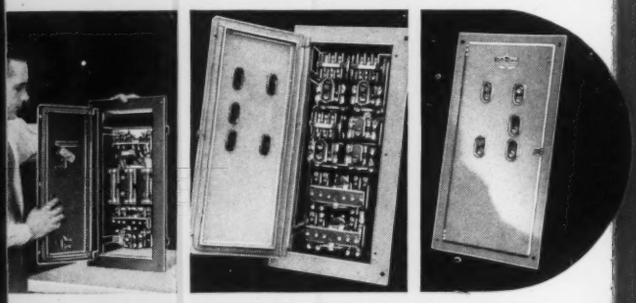

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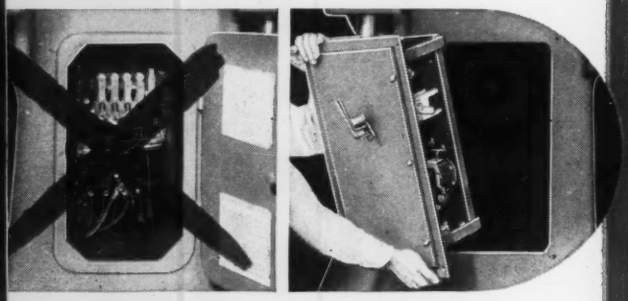

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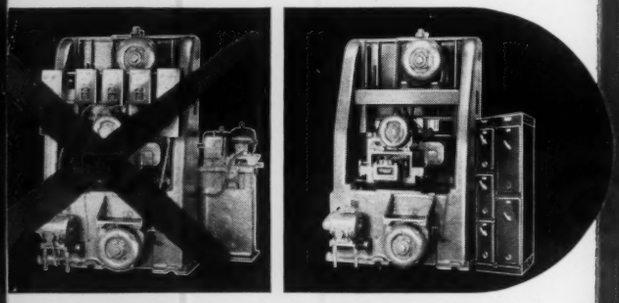

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MACHINE DESIGN

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Volume 14 JUNE, 1942 Number 6

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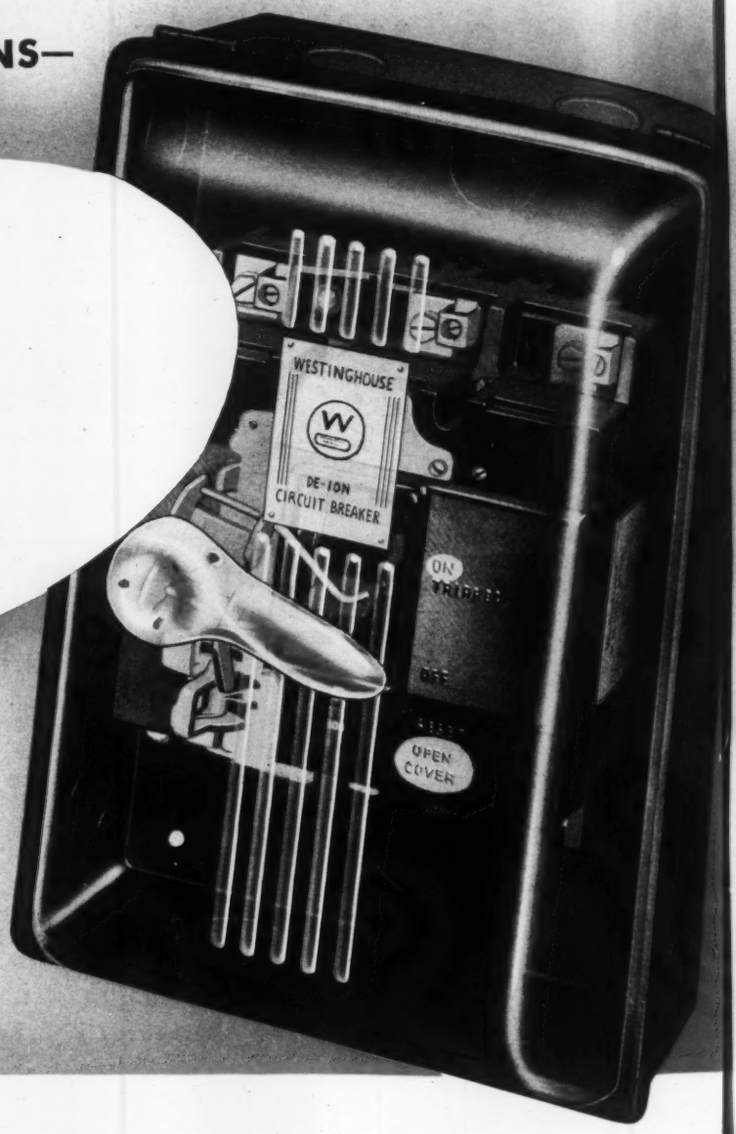
FEWER INTERRUPTIONS—

SHORTER INTERRUPTIONS—

saves time FOR MEN

AND MACHINES!



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You get FEWER service interruptions with the AB-I Circuit Breaker on the job, because its accurate, unvarying Bi-metal protection acts ONLY when the circuit is actually threatened. Momentary or harmless overloads, as when motors are started across-the-line, won't cause unnecessary time outs.

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Minutes mean money when machines are out of action. Install these Westinghouse time savers on important circuits and pay for them in lost time saved! Easy to install—ratings from 15 to 600 amperes, according to commercial wire sizes—enclosures for any service. Call your nearest Westinghouse Agent—today! Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. J-21187-A

HERE'S HOW WESTINGHOUSE BI-METAL PROTECTS PRODUCTION CIRCUITS

Two different metals bonded together and affected differently by heat, bend with a curling action under dangerous overloads. This action trips the interrupting mechanism of the "De-ion" breaker, opening the circuit before dangerous current values are reached.

Westinghouse

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Classified for Convenience when Studying Specific Design Problems

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How to Conserve Stainless Steel and Increase War Production!

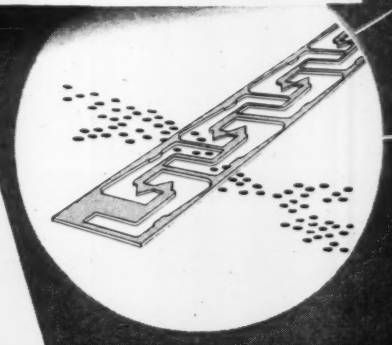
When you were turning out war equipment and parts in smaller numbers, Stainless Steel scrap losses in fabrication involved fewer pounds of vital metals. But now that output has leaped into mass production, scrap losses must be reduced to an absolute minimum.

With nickel and chromium so precious to our war needs, it is vitally important that you check your fabricating methods at every point. Waste is terrifically expensive in loss of time and strategic materials.

Helping to get the most out of every pound of Stainless Steel is a part of Carpenter's Wartime job. The knowledge and experience we have gained from pioneering the fabrication and use of Stainless Steels is now being offered to you. Let your Carpenter representative help you check your tools, dies and lubricants—to make sure your set-up is right for maximum production from a minimum of material. Meanwhile, here are specific suggestions to help you speed war production and conserve material. Be sure to check these points in your plant now! Time is short!

Check your Scrap Losses

If you are blanking, forming or drawing parts from sheet, find out if using a narrow strip could eliminate slitting and reduce your scrap loss. One plant reported a 40% material saving by adopting strip to the specified width for the particular part. Jobs were laid out more economically, and time spent handling material was reduced. The accurate gauges and tolerances of Stainless Strip save wear on dies and reduce rejects.



Carpenter

BRANCHES AT Chicago, Cleveland,

Here is a LIE DETECTOR *for* SPRINGS

SPRING NEWS

When the heavy DC current passes axially through the cross section of the specimen a circular magnetic field is produced. The action of the current is only instantaneous, so that the magnetic field disappears when the magnetic reluctance is uniform throughout the cross section. However, any break in the circular path, such as would be produced by a seam, creates a bipolar permanent field at that point. Fine iron powder dusted on to the specimen will be held in place only where this field exists.

WIRE used in making springs is usually subjected by reliable spring makers to a number of tests . . by Hunter, for example, to a tensile test, twist test, bend test, hardness test—and many others. Yet even these tests do not reveal a category of defects known simply as "seams". The detection of seams involves a scientific method known as Magnaflux inspection. Sketchily, the procedure consists of magnetizing the spring, powdering with iron "dust", and inspection. This method is used to test samples of wire, for "jump" inspection of springs, and occasionally for 100% inspection. A lot of fuss to make over a spring? Not at all. Hunter makes such tests to catch flaws and learn why they occur, to aid in improving materials, to deliver the best springs scientific manufacture can produce for you.

HUNTER

Science in Springs

HUNTER PRESSED STEEL COMPANY, LANSDALE, PENNA.

Topics

APPLIED research in war contains greater potentialities for outstanding developments than in peace. "Attainment of war objectives often forces research into wholly new fields and provides new viewpoints of old fields," according to L. A. Hawkins, General Electric Co. "In normal times it is the more fundamental researches which yield the more radically new developments. But such researches, from their very nature, lack definite practical objectives, and often must extend over many years. Both characteristics tend to prohibit fundamental research in wartime. Today there are too many definite objectives calling urgently for immediate attainment to permit dispersive pioneering and quick results are worth infinitely more than results indefinitely postponed." One of the world's greatest crimes, however, lies in the fact that the horrors of war seem to be essential to such speed-up in application of fundamental research.

♦

ONLY one coat of primer or sealer may now be applied to new metalworking equipment. No filler may be applied and not more than two coats of paint, enamel or lacquer. Any color other than "old machine-tool gray" for the final coat of paint is prohibited by the War Production Board, to reduce the time required for delivery and release space occupied by finishing departments for more essential work.

♦

HIGH-SPEED production of army tanks involving fabrication by flash welding methods may soon become a reality if present plans mature. High hopes are being expressed because, if production becomes a fact, invaluable time will be saved and tanks in greatly multiplied quantities will be available.

♦

NITRIC acid treatment for stainless steel may be supplanted by a treatment of hydrochloric acid with an inhibitor, thus releasing quantities of nitric for the manufacture of explosives. The acid treatment etches the microscopic peaks in the surface to improve the characteristics and give a smoother surface with a silvery appearance. Acid treatment must be such, however, as not to etch the valleys between the peaks.

♦

TAPPING a new source of conversion for war production, Westinghouse has placed a subcontract with Purdue University. The machine shops formerly used for routine practice work are now a war production factory. Students have become part-time workers and the instructors are shop foremen. Organized on a strictly production basis, the program involves 275 students producing the equivalent of a 75-man machine shop working full time. Special materials are supplied by the contractor and others are obtained by the university with a priority rating from the War Production Board.

♦

TO INCREASE its salvage capacity for reclaiming strategic alloys from steel grindings, Allegheny Ludlum Steel Corp. is building a new reclamation plant which will concentrate on the processing of steel grindings to save the alloy content.

♦

SEARCH for new sources of strategic and critical materials has uncovered a rich fund of tungsten in sections of the Salmon River country in Idaho. This find alone is supplying about five per cent of U. S. requirements and assures more liberal use for high production on machine tools.

♦

FOUR series of translating screw threads have been approved by the American Standards Assn. Those covered are: General purpose Acme threads with an angle of 29 degrees between the sides of the thread; 29-degree stub thread; 60-degree stub thread; modified square thread with a 10-degree angle between the sides of the thread. Because of the importance of this standard in the war effort the British Standards Institution also is considering its adoption.

War Substitutions Can Be Permanent!

By R. E. Orton
Chief Engineer
Acme Steel Co., Chicago

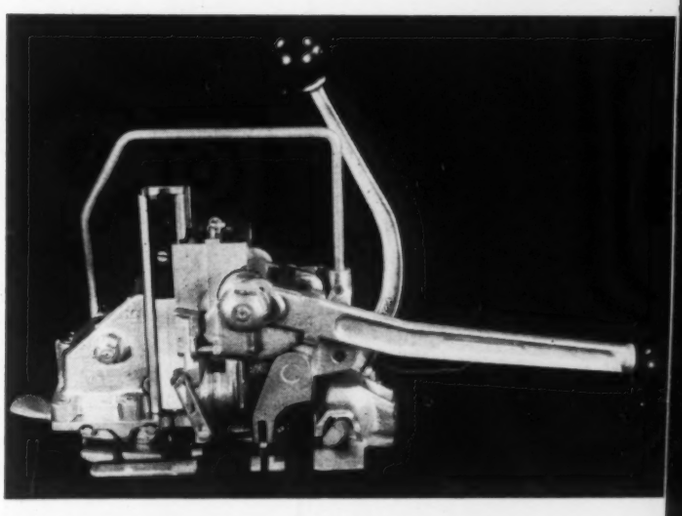


Fig. 1—Redesigned parts on hand machine utilize available materials as well as prove superior to original designs

SHORTAGES created by the war have forced a search far afield for new materials and new ways of making old products. While in many cases substitutions must be accepted which are inferior to the original, frequently the ingenuity and skill of machine designers have developed improved designs or reduced costs. These results have been achieved, in the main, by careful search and study of all possible substitutions and by the attitude that a substitution need not be inferior. Even though the original choice may have been the best at the time it was made, processes change and new materials and methods continually are be-being evolved. A fresh view point frequently leads to fruitful results.

Typical of this was the problem of substitution for several parts of the hand-operated box strapping machine shown in *Fig.* 1. It consists of a magazine from which seals are fed into the jaws of a sealing member. The sealing member, when actuated by its handle, slides on the magazine into position to seal the ends of the strapping band. Thus, it is necessary for the magazine to take the reactive torque from the sealing effort at the time the joint is sealed. The original magazine and its loading is illustrated in *Fig.* 2 to show the

features of its design and its general shape.

These magazines previously had been produced from extruded 53*S*-*T* aluminum alloy, cut to length and machined. The small quantity needed, together with the requirement of minimum increase in weight, appeared to limit the possible substitutions. After considering many methods and materials it was felt that forming in successive stages on separate dies from strip steel offered good possibilities despite the relatively low production. Extruded magazine and redesigned formed magazine are shown in *Fig.* 3.

As a first approach, study was made of the basic shape shown by dotted lines in *Fig.* 4. Analysis revealed that the part could be materially simplified by the elimination of the "wing" at the front. While this wing was intended to carry part of the sealer load, its low rigidity due to the way it was carried by the thin wall of the magazine forced nearly all the reaction onto the back wing, so that the utility of the part was in no way impaired by the removal of the front wing.

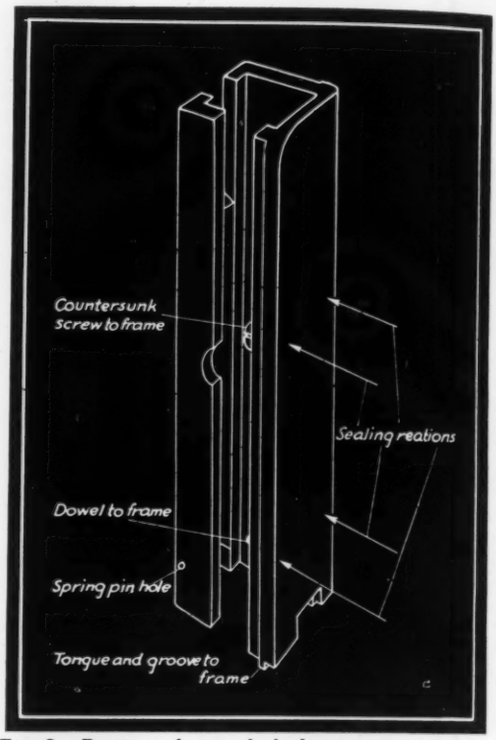


Fig. 2—Design of extruded aluminum magazine indicating loading reactions

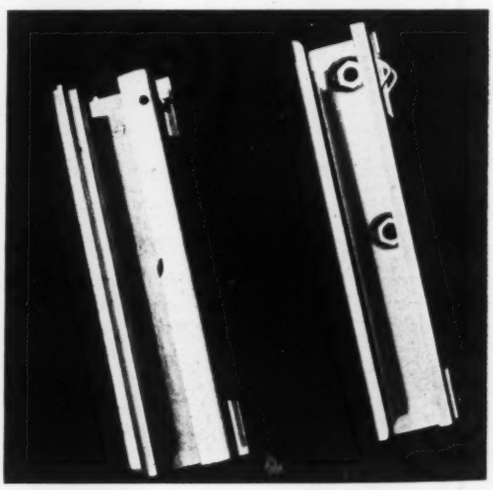


Fig. 3—Extruded aluminum magazine is at left—simplified redesign using two stamped parts is shown at right

Folded Joint Gives Necessary Strength

To obtain the same weight as the aluminum part it was necessary to use a stock thickness of about .06-inch. This meant that the thickness of .18-inch required at the back wing could not be obtained by a simple folding back to a double thickness. While a fill piece might have been used, it was felt that it would simplify production to divide into two pieces and fold together, as illustrated by the solid section in *Fig.* 4. Stock, specially selected for bending qualities, is low-carbon, cold-rolled, dead-soft sheet steel, followed by a pinch pass.

Locking of the two forms together is secured by first punching three holes along the edge of Shape II and then extruding metal from the fold of Shape I into these holes, as shown in the sectional sketch, *Fig.* 5. The two forms are assembled in a fixture and positioned in place by hand-operated cams. Fixture contains three punches located over the three holes in Shape II. Punch press is then used to force the three punches to extrude the metal into the holes, forming the "punch-locked" joint.

The aluminum magazine was assembled to the main frame by a countersunk screw, a dowel, and a tongue and groove joint, as shown in *Fig.* 2. None of these methods is feasible on the steel part because of the thinness of the material. Analysis showed that the accuracy of the dowel and tongue was not necessary, so two heat-treated screws with thin hex heads were substituted. Screws are set into hex-shaped indents in the magazine wall. This offset served also to fill the gap left by the use of the thinner material. Screw holes are pierced after the extrusion to eliminate stretching of the hole. This is done in a single operation by the use of hollow hex-shaped extrusion punches into which the piercing punches are placed after performing the extrusion. The fastening arrangement is illustrated in detail in the partial section shown in *Fig.* 6.

At the lower end of the aluminum magazine, a drilled hole held a pin, *Fig.* 2, which retained the lower end of the spring used to pull down a "seal weight." This function is accomplished on the steel magazine by the detail shown in *Fig.* 7. There remain several notching operations to form the seal exit and other openings. These are performed at various stages of the forming, and again with the use of hand-fed dies. These keep the costs of tooling at a minimum.

Set-up charge amounts to less than 14 per cent of the production cost because all dies are mounted in separate die sets, giving a simple mounting operation to install on the press. The total saving

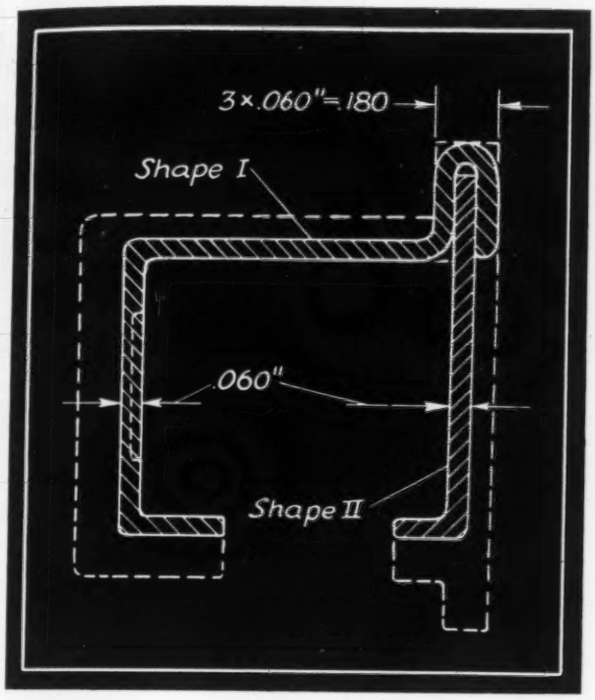
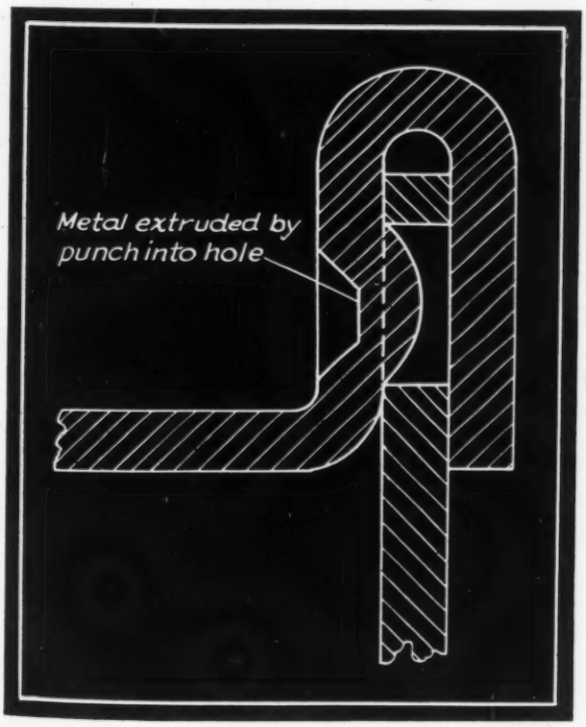


Fig. 4—Sectional drawing of new magazine of formed strip steel is superimposed on section of previous design which is shown dotted. The simplification effected is apparent in this comparison

Fig. 5—Detail of punch-locked joint for assembling stamped shapes. Three such crimps along the back wing provide a rigid assembly as well as necessary thickness required for strength



effected through the use of a formed magazine over the former design amounts to nearly 80 per cent and the strip steel magazine weighs only a "shade" more than the aluminum. The part itself is stronger, and has proved entirely satisfactory in the field. In addition, a problem of wearing of the lip of the aluminum part at the point where the seals "feed out" was eliminated by the change in the material. This redesign therefore has resulted not only in a greatly reduced cost but in a substantially improved product. The economies effected alone justify the change in design.

Effects Similar Savings

In *Fig.* 8 is a similar part used on a smaller size strapping machine. On the left is the original, a zinc die casting containing an inserted steel seal guide. On the right is the stamping that replaced it. A substantial saving in weight is effected, although the cost saving is not as pronounced as in the first case.

A feature of interest in the design of this part is the formation of the dowel shown in the mounting side, *Fig.* 9. This called for a much deeper draw than was practical, and first attempts resulted in cracking and tearing of the metal. Inasmuch as the dowels were required only to locate in a vertical direction, a narrow horizontal slot is first punched and then the dowel drawn. This gives the "fish-mouthed" affair which shows as the center hole in *Fig.* 9.

A somewhat different problem was faced in the seal weight shown in *Fig.* 10. This part is pulled down by a clock type spring onto the stack of seals in the magazine. While substitution was not necessary because of material shortage, it came under scrutiny in the general survey because of high cost. Investigation and study led to the selection of a thermosetting, high impact, mineral-filled phenolic plastic. The plastic part is shown at the right of the part it replaced in *Fig.* 10. It is molded complete, followed only by a simple drilling operation. Careful stress analysis was necessary to avoid failure with the weaker and more brittle material. Generous fillets are provided at the projecting legs, and all corners are carefully rounded. It was also necessary to redesign the shape, to permit molding. Because of this the construction of the spring center pin was altered. Here again a substantial saving in weight and cost results in another permanent substitution.

Forged Steel Replaces Aluminum Forging

At the top of *Fig.* 12 is a tool for performing a sealing operation only. An important feature of this tool is its light weight. The handles, of 14*ST* forged and heat-treated aluminum alloy, imposed a serious problem in substitution because of the need of keeping the weight down to somewhere

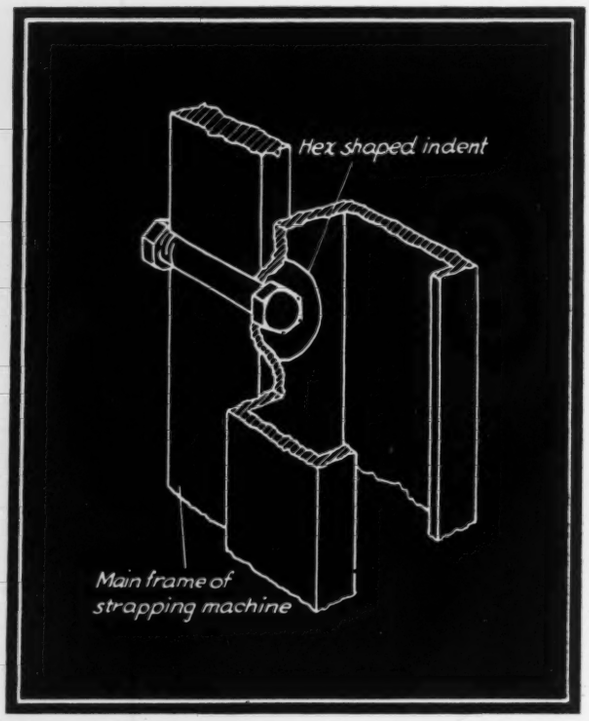
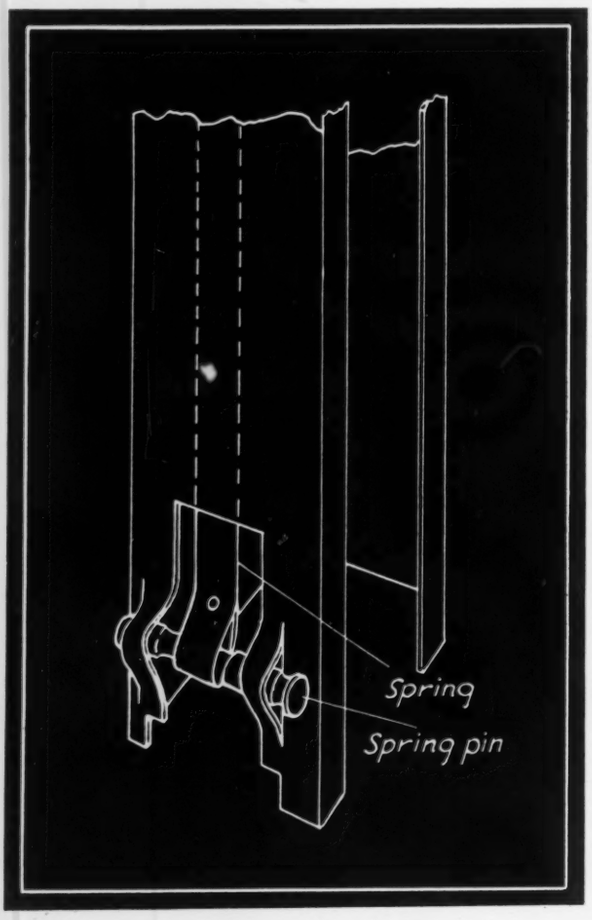


Fig. 6—Hex-shaped indents provide for fastening with screw instead of a countersunk screw and dowel

Fig. 7—Method of attaching pin for retaining spring end



near that of the original design.

Inasmuch as all light alloys are critical materials the only possibility was the use of steel, relying upon its higher strength to hold the weight within acceptable limits. Computations showed that a handle of heat-treated alloy steel would weigh little more than the finished aluminum handle. However, the sections would be too small for satisfactory forging and the machining appeared totally impractical. Moreover, it was felt that such a choice would be a mistake because of the obvious need for conservation of more critical alloying materials.

Investigation was then made of a 45-point carbon steel, forged and normalized to 250 Brinell hardness. This is an easily obtainable steel and a simple

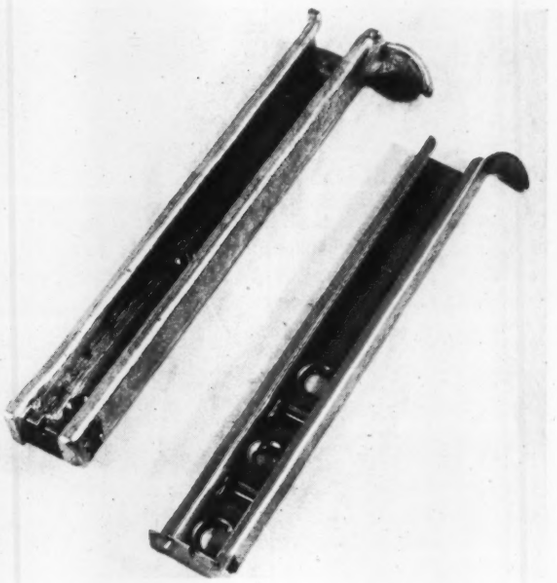
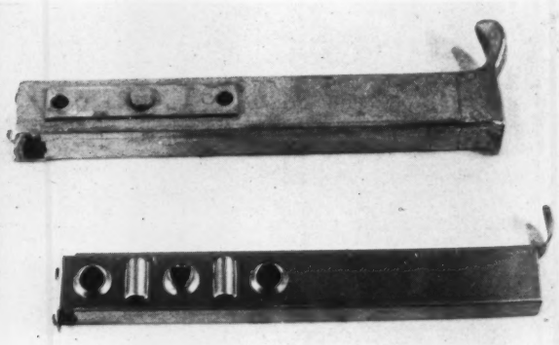


Fig. 8—Redesigned magazine shown at right for smaller machine also makes use of stampings

Fig. 9—Back view of small magazine shows details of stamping, below, compared with previous design



heat treatment. The handles, forged and machined, in *Fig.* 11 was then designed. This represented a balance in sections between that required to carry the load and the minimum practical to machine.

The machining was recognized as a serious problem, but it was decided to take the risk and proceed.

The forgings as produced were a disappointment. Instead of the 250 Brinell, less than 150 was attained. The forgings were so soft that machining was difficult, mere handling damaging the parts, and the threading of the end for the handle ball caused the I-section to twist in spite of all efforts to hold. Therefore it was decided to experiment with a mild heat treatment, machining after the heat treating.

Inasmuch as the section to be machined is fairly heavy compared with the unmachined, where the strength is required, an oil quench was tried. Because unalloyed carbon steel hardens fully in oil

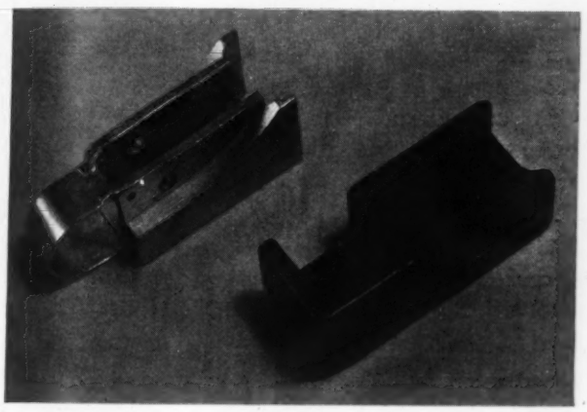


Fig. 10—Machined steel seal weight is replaced by molded phenolic at right

only up to a certain minimum section, which in this case lay between the machined and unmachined sections of the forging, it was found on drawing back to 800 degrees that the hardness of the machined portions could be maintained under 260 Brinell, while the hardness of the high stress sections was over 350 Brinell, after the draw. This heat treatment increases the strength of the thin section to suitable levels while still leaving the other sections in a satisfactorily machinable condition. In fact, machining is actually slightly improved as the newer material cuts much more freely.

With this change, only 4½ ounces or about 15 per cent, is added to the tool weight, and this additional weight is so placed as actually to improve the tool balance. Appearance also is improved, the redesign giving the effect of an even lighter weight. These new handles are appreciably stronger than forged aluminum although not quite as stiff. This reduced stiffness, or greater "springiness" is, however, a desirable feature, producing a live action in use.

The steel forgings are materially cheaper than the aluminum, with machining costs about the same. In the redesign it was found possible to incorporate a "stop pin" in the handle, so that a

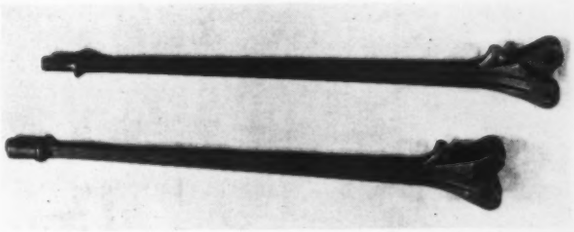


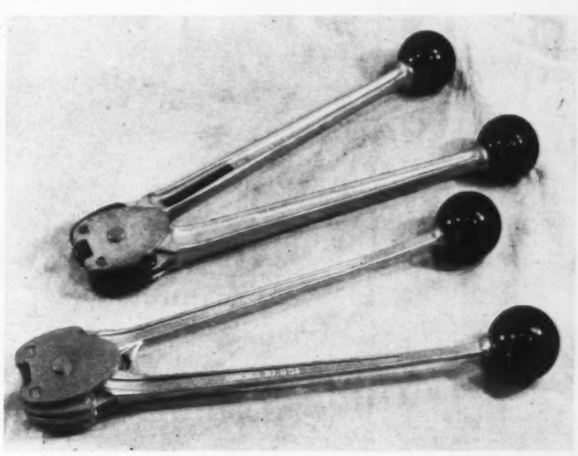
Fig. 11—Forgings of steel, heat-treated replace aluminum alloy for handles and incorporate integral stop pins

substantial net saving resulted for the entire tool. Inasmuch as the redesign provides an improvement as well as a reduction in cost, another permanent substitution—rather than a temporary expedient—has been effected.

It is not intended to infer that aluminum is inferior to the replacing materials, nor that the displaced methods of construction are necessarily wrong. Rather, that materials and methods are frequently misapplied, particularly in the light of rapidly changing conditions. Indeed, there are undoubtedly many places where aluminum would be the proper choice. However, exigencies of the war make such considerations inadvisable at the present time. After the war, a careful search can be made in the light of conditions existing at that time.

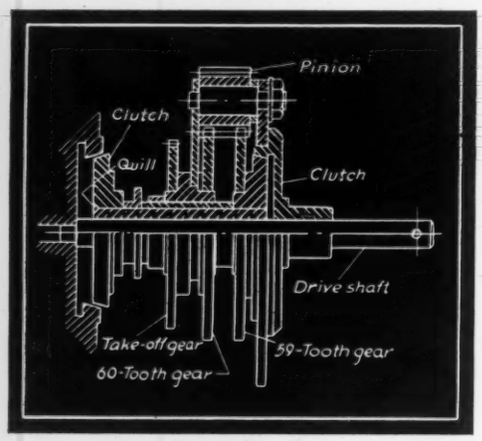
Generally there are many ways of building a part, and several materials may be used. If the first design or material that comes to mind is selected the designer will often find, on later study, that the selection has not been the wisest. Frequently the picture, as in the present instance, has changed radically since the development of the original machine. Designers have an excellent opportunity to aid the war program by carefully re-examining their machines in order not only to improve them but to effect all possible conservation of critical and strategic materials which are needed for more vital tasks.

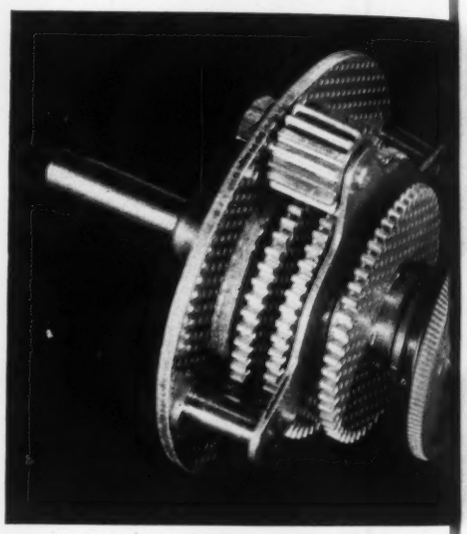
Fig. 12—Former hand tool with aluminum alloy handles at top and new tool with forged and heat treated steel below. New design is stronger, has "live" action



Scanning the field for IDEAS

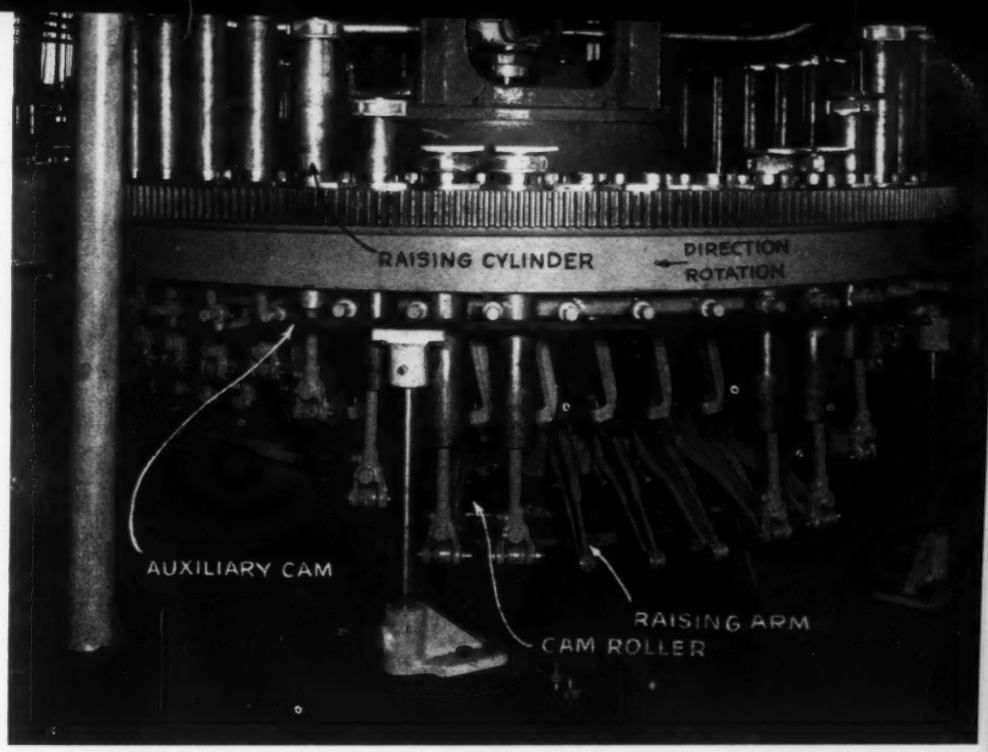
Direct drive or a reduction is obtained on a common axis in the gear unit at right for a timing mechanism of an Esterline-Angus Co. recording instrument. In the position shown in the drawing, the right cone clutch is engaged for direct drive, with the left cone clutch disengaged. The entire differential is locked together so that the drive shaft and the take-off revolve at the same speed.





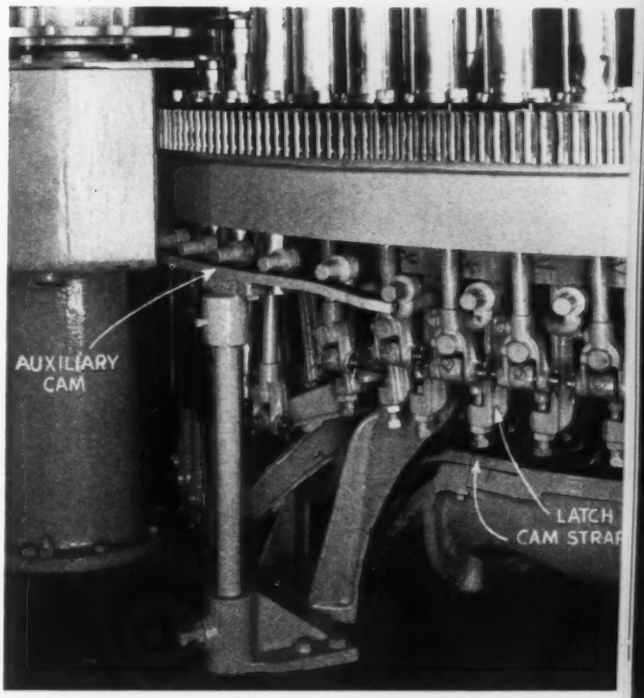
For 60:1 reduction the engagement of the clutches is reversed by shifting the quill. Because the female member of the now engaged clutch is stationary, the 59 tooth gear being on the quill will also be held stationary. This causes the planet pinion to revolve around the 59 and 60-tooth gears causing the latter to advance one tooth or 1/60 revolution for each revolution of the drive shaft and the pinion carrier.

Apprehension of saboteurs is the duty of small acoustic units mounted on fences around war production plants. Consisting of magnetic pickups sensitive to minute vibrations in the vicinity of the fence, the instruments flash a warning signal at a central station in event of any disturbance. Coupled with a sentinel system these protective devices, designed by the E. I. du Pont de Nemours and Co., mounted every thousand feet provide a method of protection which appears to be foolproof. Sentinels in making rounds can tap reports to headquarters from any position on or near the fence.



Latching system provides a simple and interesting method of friction-load reduction in a rotary bottle-filling machine designed by the Liquid Carbonic Corp. The rotating spider, 70 inches in diameter, houses 50 reciprocating bottle-raising and lowering cylinders. Within each cylinder is a crosshead and connecting rod and, also, a stop ring near the bottom to prevent the crosshead from sliding out of the cylinder. Between the top of the cylinder and the crosshead is interposed a spring having an initial compression of 80 pounds to seal the bottle against an internal pressure ranging from 20 to 30 pounds when lifted by the raising cylinder into engagement with a filling valve.

Rotation of the spider causes the cylinders and bottles thereon to be lifted into engagement with the valves. The cylinders are lifted by a raising arm and cam roller assembly connected to the fork of the connecting rod. The raising arm cam roller engages a hardened steel cam strap on the raising side of the cam shown in the upper photograph which has three connecting rods and cylinders removed to show the assembly.



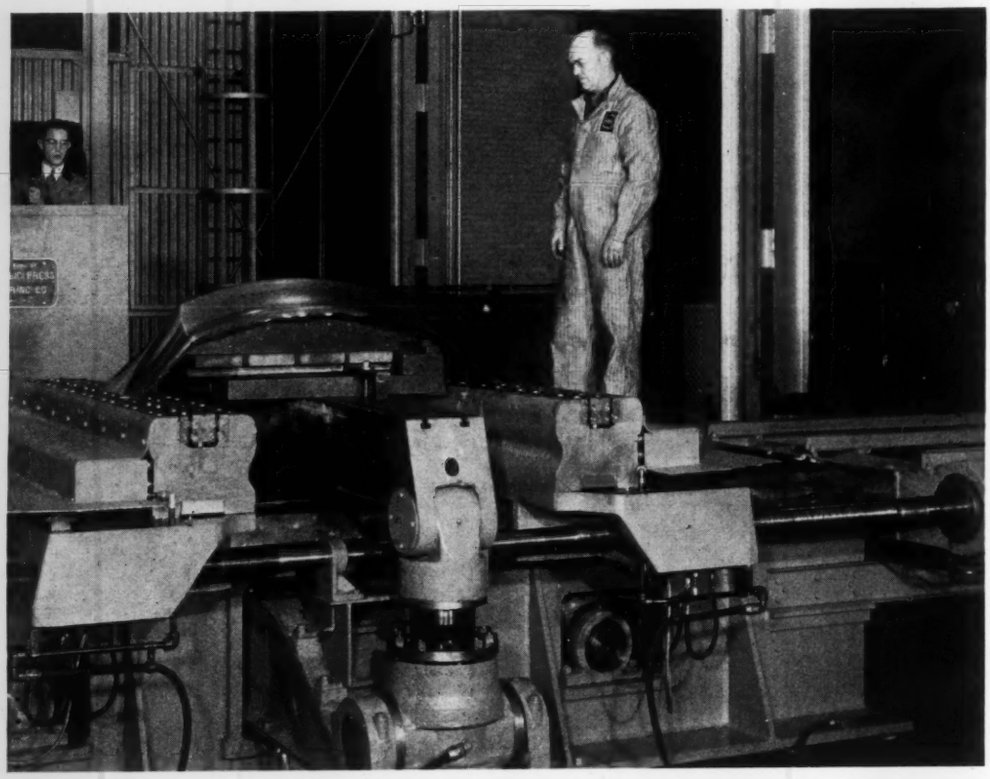
As the cam rollers and raising arms approach the highest point on the raising cam, the latches start to swing by gravity under the raising arm, at which point the arm is just above the dog-point setscrew in the latch, and in its highest position. Beyond this point, the cam strap is declining, thus permitting the raising arm to drop on top of the dog-point setscrew and so be held up. In the latch position the cam roller does not touch the cam. While latching of the raising arm is taking place, the spring within the raising cylinder is compressed one inch. This compression amounts to 18½ pounds and is necessary to seal the bottle against the filling valve. Thus the latched raising arm is supporting the spring load. Without the latch, this load would be imposed on the cam roller and cam.

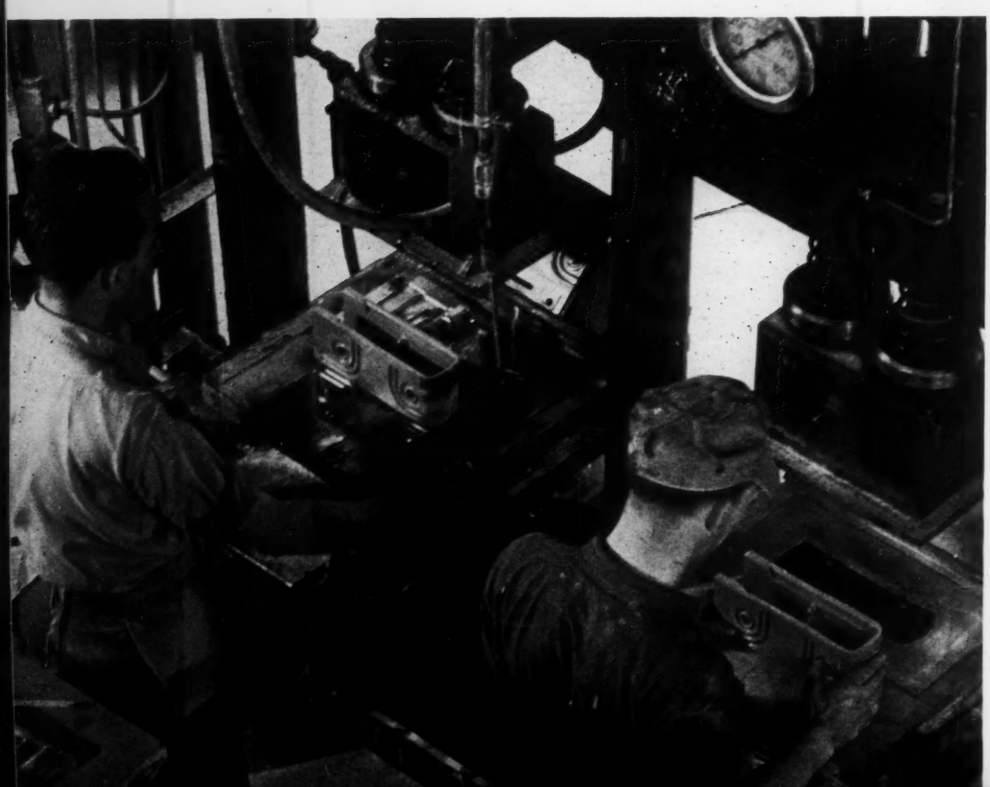
When the cam roller reaches the highest point on the discharge cam strap, the raising arm is raised by the cam about 1/16-inch above the dog-point setscrew in the latch, thus disengaging the latch. About the same time, the hardened pin on the latch engages the incline of the auxiliary cam, thus swinging the latch from underneath the raising arm. The raising arm is now free to follow the discharge cam strap and lower the raising cylinder and the filled bottle thereon. The latch remains in the unlatched position until the corresponding cam roller again reaches the latching position.

During the interval between the discharge and infeed, there are nine inactive cylinders and corresponding filling valves and, of course, nine unlatched raising arms. The springs in these nine inactive cylinders are relieved of the one-inch additional compression because the bottles on these cylinders are out of engagement with the filling valves. Thus no spring load is imposed on the cam rollers and cam during the interval between discharge and infeed. Since there are nine inactive raising cylinders, each having a one-inch spring compression of 18½ pounds, the total spring load of the 41 active cylinders is 758.5 pounds. Thus a saving of 1.4 horsepower is realized.

Metal stretcher forms aircraft parts by clamping ends of a sheet and pressing an inexpensive form against the sheet as shown below. Developed by Hydraulic Press Manufacturing Co., conventional, expensive die is obviated and instead a wooden form or a nonferrous alloy of the Kirksite type is used. Especially adaptable for small runs where conventional die costs per piece would be high and where excessive trim of stock is offset by the decrease in die cost, this skin stretcher will also be useful in development work to determine readily the best shape for a part.

Clamping and forming operations are hydraulic. Position of the clamping jaws, however, is adjusted by four gearmotors, one at each corner, driving threaded shafts. Hydraulically energized toggle joints clamp the sheet in the jaws by forcing a crimp in the sheet against a bead in the jaw. The form is held on the movable platen and is controlled by double-acting hydraulic cylinders at each end. To control the stretching, these cylinders are independently operated as is also a secondary movement of jaws, controlled by four hydraulic cylinders. These provide maximum flexibility and give the operator complete control during forming. If reverse draw work is desired, an accessory overhead die is provided.





New engineering materials compounded of highly-available ingredients are now releasing critical metals for important war work. Typical of such developments is Prestite, a porcelain capable of being formed accurately to intricate shapes as shown at left. When cold molded and fired like a porcelain, it is mechanically as strong in compression as wet-process porcelain. Molded parts retain their mechanical strength without deformation at temperatures that would completely destroy phenolics.

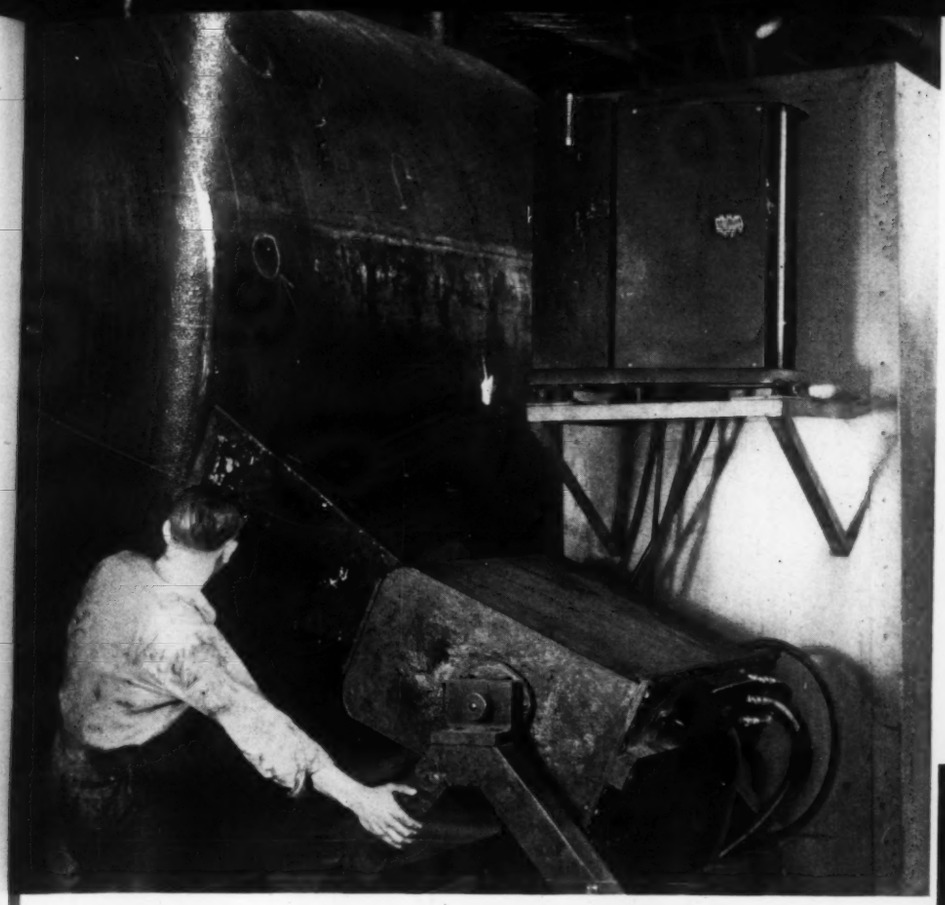
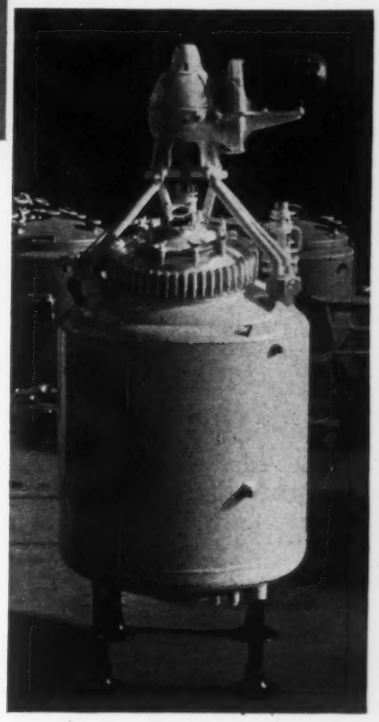


Fig. 1—Left—Radiographing girth weld on high-pressure vessel to insure against faulty welds and possible failure in service

Fig. 2—Below—Porcelain enameled, jacketed autocalve for acids requires special considerations



Synthetics Increase Demands on Pressure Vessels

By John W. Greve

WITH the growing importance of synthetics and increasing demands for chemical products, pressure vessels and processing tanks have major uses in practically every industry. For each special application, however, there are as many possible designs as there could be engineers assigned to develop a unit.

Today's high working pressures are possible only through the application of welding techniques and ability to sample or inspect joints by methods such as trepanning and radiography, *Fig.* 1. Not only must vessels withstand extremes of temperatures and pressures but also special conditions of oxidation, reduction, corrosion, diffusion of gases through metal and propensity of hydrogen to remove carbon from steel. This article will discuss generally the considerations in the selection of vessels, including air and hydraulic accumulators, and their basic types of design.

Selection of material for a vessel requires that

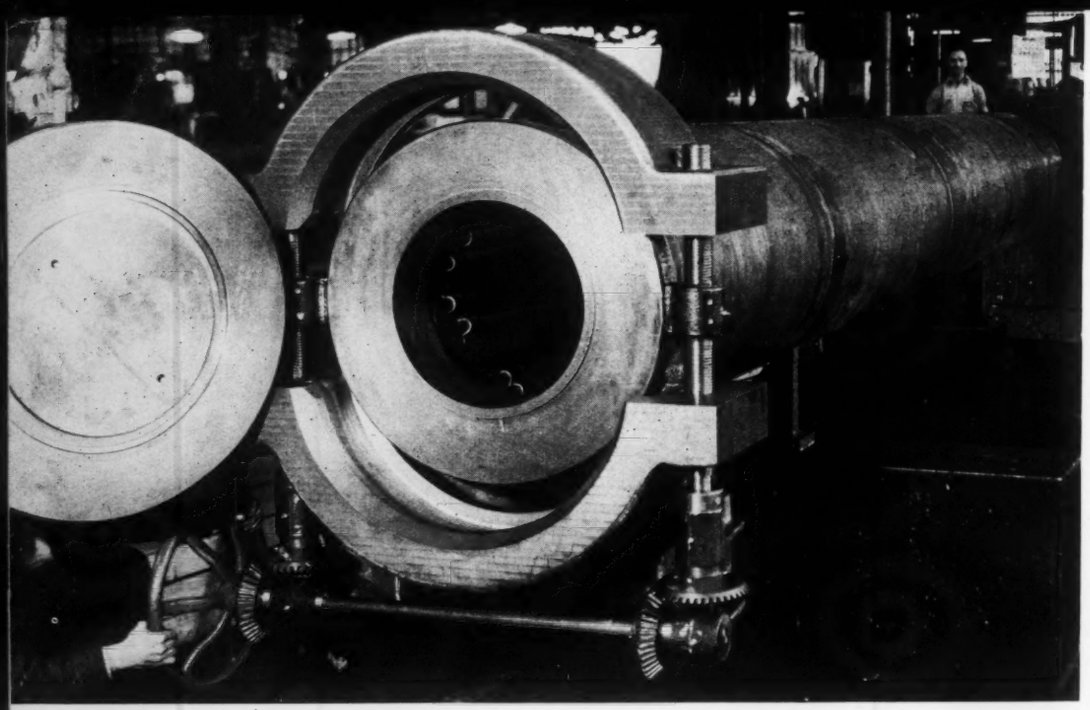


Fig. 3—Left—Prestressed principle, applied to multi-layer pressure vessel, conserves material. Quick-closing head is built up on same principle

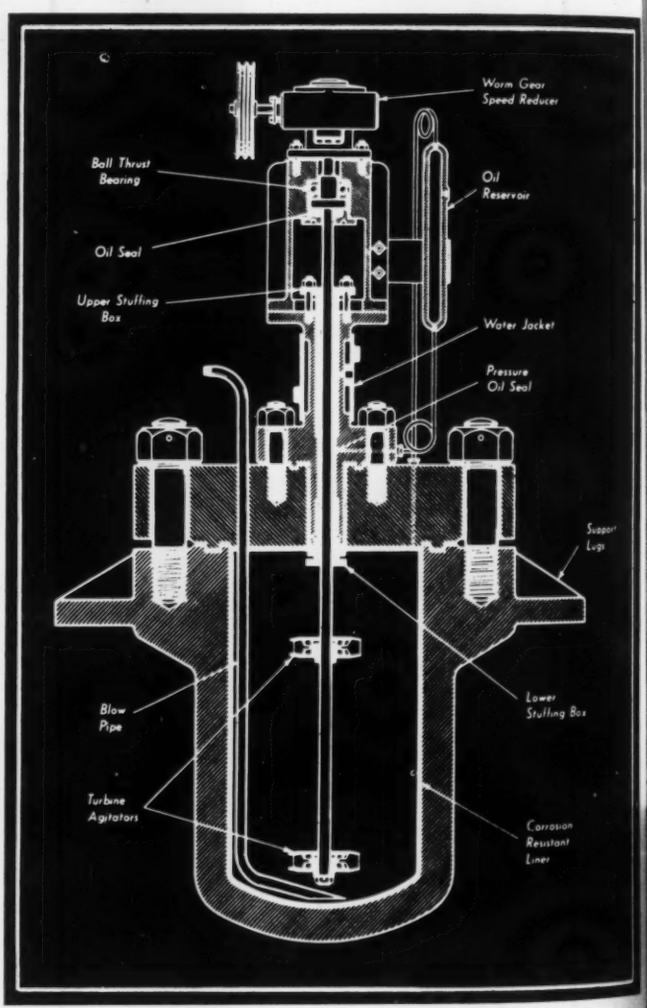
Fig. 4—Below—Cross section of autoclave showing liner, agitator, stuffing box and head fastening arrangement

it be sufficiently strong to withstand the working pressures and temperatures as well as the corrosive effects of the materials being processed. An excellent summary* by A. Grodner covers materials available for pressure vessels and considerations for their application. Often a high strength alloy may prove more economical from the cost standpoint, considering savings in weight with resultant reductions in supports, foundation, etc.

Provides Corrosion Factor

With respect to corrosion the proposed ASME code revision provides for a factor c for air, steam and water vessels constructed of steel plate where c is equal to $t/6$ but need not exceed 1/16-inch. This allowance is designed to be "great enough to obtain the desired life of the vessel". Because steels are corrosive in many processes, liners of materials not strong in themselves are used, such as copper, aluminum, lead, silver, gold or glass. Liners as inserts do not of course increase the strength of a design. In fact they must be applied with care to insure against gas pockets that would collapse the liner on application of heat or reduction of pressure. For stainless clad steels however, the code recognizes the composite strength of the steel in determining wall thickness. Design charts† for quickly selecting required thickness are useful in designing vessels.

Unavailability of stainless has given impetus to the use of vitreous enameled vessels which have been developed to a high degree of servicability. They cost as little as one-third that of stainless. In these units, enamel with a coefficient of expansion close to steel is processed on sand-blast, low-carbon steel to provide a chemically inert lining that is resistant to all acids except hydrofluoric and hot phosphoric. Enamel being fragile, protection should be provided against accident such as sudden impact of heavy objects. These vessels will withstand thermal shock of 175 degrees Fahr. without harm and are suitable for service up to



*"Specifying Materials in Design of Pressure Vessels", MACHINE DESIGN, Page 45, August, 1941.

†"Determining Wall Thickness for Pressure Vessels"—J. Marin, MACHINE DESIGN, April, 1942 and "Designing High Pressure Vessels and Piping"—J. Marin, MACHINE DESIGN, May, 1942.

550 degrees Fahr. Enameling requires careful design for uniform sections, minimum radii of ½-inch on edges of flanges, agitators, etc., smooth welds and minimum distortion. Such a vessel is shown in *Fig.* 2.

Electrical tests disclose any minute imperfections in the lining. These are then enlarged by drilling and filled with gold in much the same manner as a dentist fills teeth. Gold-filled holes are acceptable for most kinds of service excepting aqua regia and bromines.

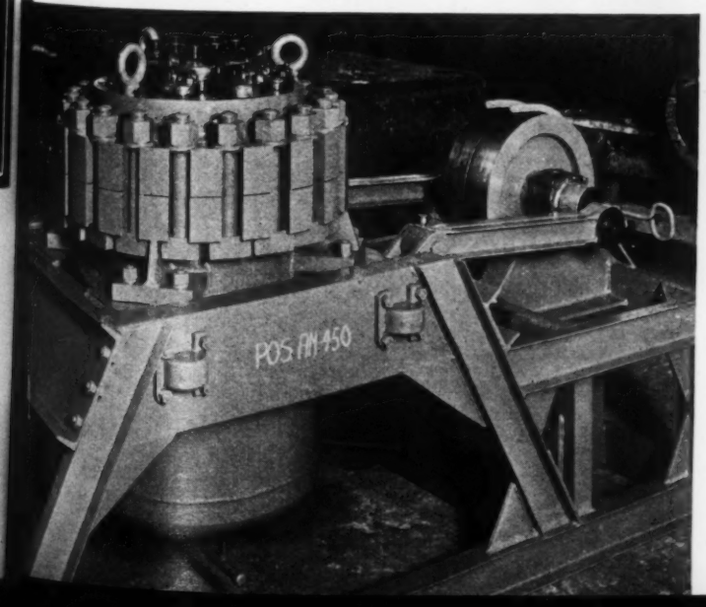
Multilayer Design Saves Material

Similar in principle to the auto frettage used in gun design, is a multilayer vessel utilizing thin concentric welded shells instead of shrink-fitted, forged hoops as in the guns. Each shell is mechanically tightened to provide a definite compression on the inner layers so that, at operating pressure, the stress will be uniform across the wall section. In this way the amount of steel necessary for a given operating stress is reduced, an important factor in itself when materials are critical.

A vessel of this type is shown in *Fig.* 3. Designed to operate at pressures above 5,000 pounds per square inch, each layer is less than ¼-inch thick except the innermost. Only that layer need be leakproof and corrosion proof. Each subsequent layer is vented so that any entrapped moisture may be expelled if elevated temperature is in the operating cycle. Also, if the inner layer fails from corrosion the pressure will slowly subside, keeping the vessel from becoming unsafe. Each succeeding hoop then need be selected only for economical considerations for pressure and temperature. There is no limit to size and weight in manufacturing and flaws cannot be greater than the thickness of a ring; they can be readily detected by inspection before fabrication.

Spherical heads for this vessel use a thickness one-half of that for the wall. Openings for fittings usually are placed in the head. If a flat head is desired, the principal adopted for gun

Fig. 5—Below—Agitated vessel obviates a rotating agitator, simplifying mechanical design problems



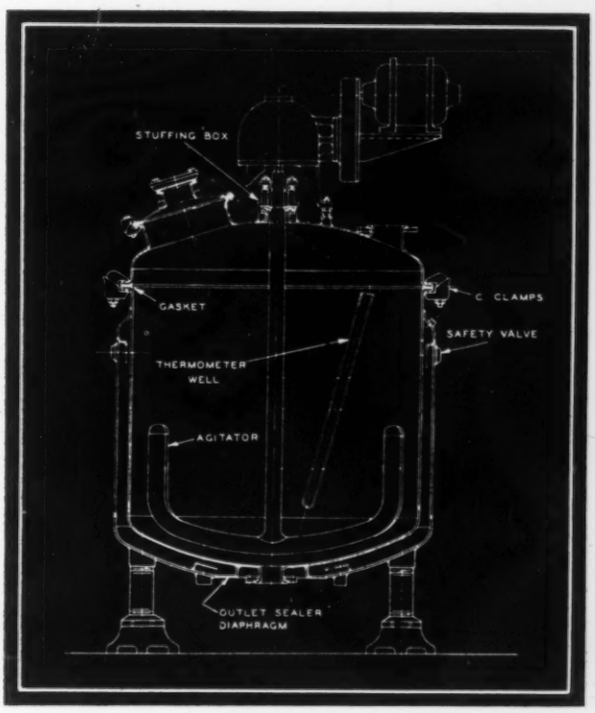
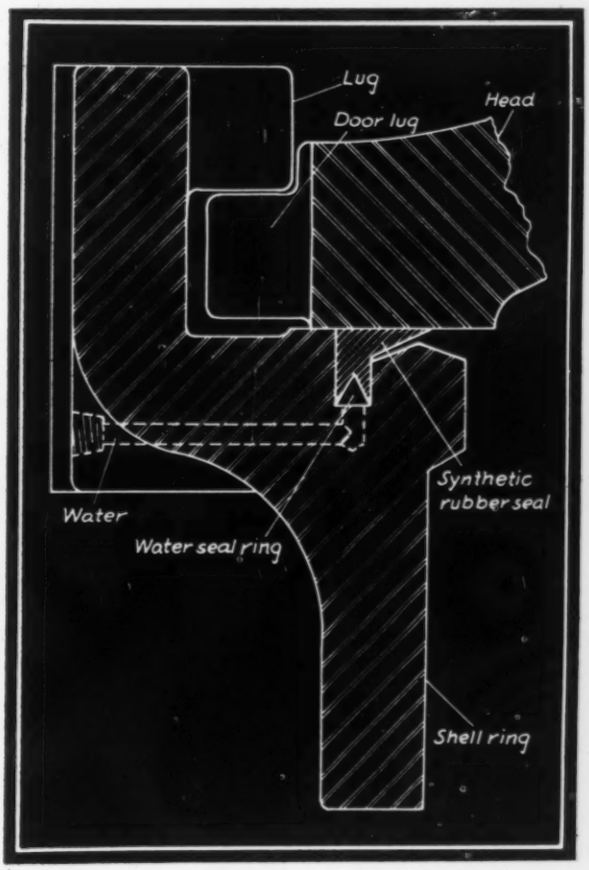


Fig. 6—Above—Jacketed vitreous enameled vessel is designed for uniformity in cross section. Jacket is welded to tank at top and bottom with diaphragm for expansion around lower outlet flange

Fig. 7—Below—Detail of quick-lock head. Lugs on head correspond to locking lugs on vessel flange. Small angular movement of head locks or unlocks it



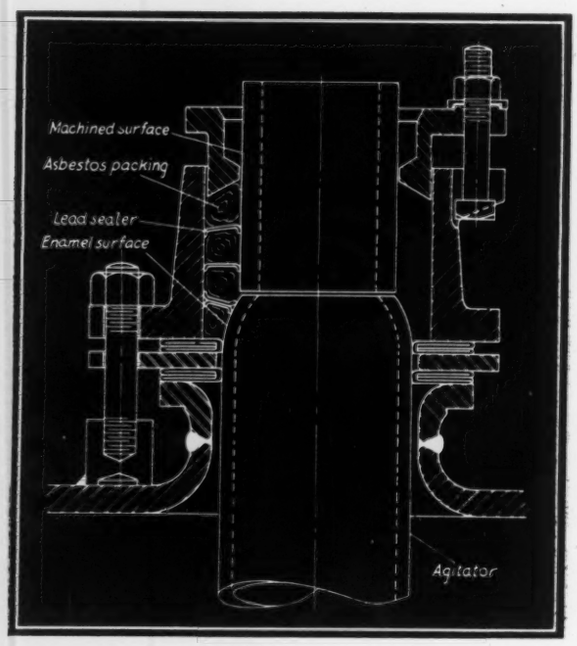


Fig. 8—Stuffing box for enameled agitator. Sealers interposed between braided asbestos packings are lead. Lower part of gland encloses enameled section, preventing vapors from corroding shaft

breech design can be applied without the necessity of a quick-opening feature. In this design, a series of forgings or cast-steel rings are machined and shrink-fitted to produce a stress effect.

Fittings for pressure vessels may be threaded with tinned threads, welded, mechanical-compression or gasketed-flange. Threads are limited to pressures under 2500 pounds per square inch. Gasketed flange joints, welded to head or wall, are required for high-pressure work, the flanges being of sufficient size for the required number and diameter of bolts. For enamel lined vessels, however, it is necessary to keep all sections uniform. For this reason separable split-flanges are utilized, allowing smaller sections on tank flange.

Electrical leads may be gasketed in many ways. One interesting method swages an outside-tapered plug containing the leads and molten glass to a cylindrical outside surface, thus tapering an originally straight hole. This fitting is satisfactory for service up to 450 degrees Cent. and 4500 pounds per square inch. Another fitting utilizes soapstone as a ferrule, compressed into conical faces by a plug forcing the ferrule into a taper in the body of the fitting.

Methods of fastening heads are many. For extremely high pressures, bolts are employed as in *Figs.* 4 and 5. In porcelain enameled vessels, C-clamps or hook clamps are placed around the flange which for fabricating reasons has been designed with uniform section as discussed previously. Special heads that are required to open quickly utilize methods such as shown in *Figs.* 3 and 7. In *Fig.* 3 the head seals against a pressure of 5000 pounds per square inch. The handwheel, geared to threaded members, operates the clamp to hold it against a tapered shoulder.

Faster acting is the head-lock shown in detail in *Fig.* 7. A five-foot head seal, it is effective on pressures of 250 to 300 pounds per square inch. Swinging on a hinge shaft and pivoting on its center, the head is closed by turning 1/20 revolution so that the lugs on the head are behind corresponding projections on the body flange. A neoprene washer seals initially against the head by an extended inner lip. Low water pressure, acting on the V-shape back of the washer, effectively completes a leakproof joint.

Agitators in vessels should properly mix the contents using a minimum amount of power and should be supported in such a way that shaft deflection and wear on the packing gland will be a minimum.

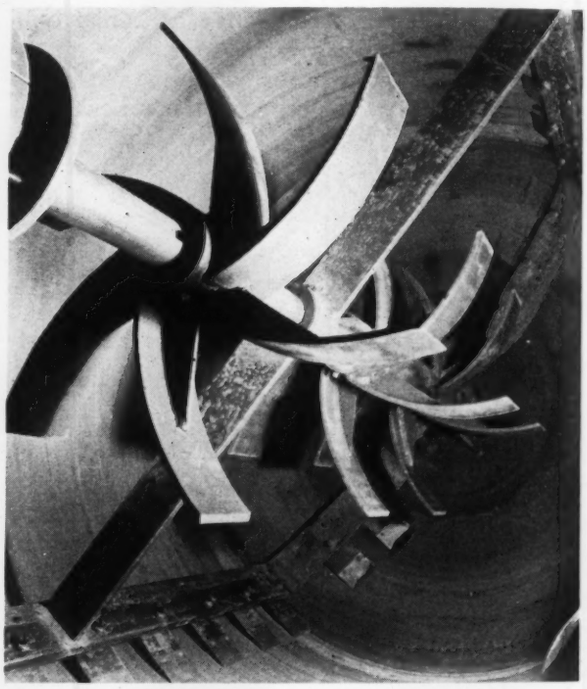


Fig. 9—Scraper unit keeps wall and bottom free from sticking materials and operates at a lower speed than the turbine agitator

Design of two styles of packing glands are shown in *Figs.* 4 and 8. The former is for a high-pressure, high temperature application and has a water-cooled jacket to extend the life of the packing rings. Also, because the unsupported section of shafting is long, an extended bushing reduces whip and wear on the glands. The latter, *Fig.* 8, shows a gland for sealing an enameled agitator. The problem is to keep corrosive vapors from the machined section beyond the spherical radius on the shaft. This is accomplished by having the lower two packing units, consisting of lubricated braided asbestos rings with lead sealers, contact the surface on the enameled section below the radius. Some enameled agitators have a replaceable sleeve assembled over the stem and against the glass.

The sleeves are plain steel or various alloys to give longer life and greater resistance. These sleeves are useful where the bare metal would be attacked by chemical action.

One method of obviating the agitator with its seals is to shake an entire autoclave as in *Fig.* 5. Flexible leads to the heating medium are relatively simple compared with the problems of an agitator. This unit, designed for a hydrogenation application, has a 45-gallon capacity and 1500 pounds per square inch working pressure.

Agitators are of many styles and have never been reduced to empirical equations for capacity and amount of mixing for various combinations of materials. Anchor types, *Fig.* 6, are often used for low-speed mixing. Impeller types operate at higher speeds. Turbine type mixers have high efficiency and, when used with a central flue, mixing is highly effective. Many agitators utilize deflectors or baffles to break up swirling. Often agitators are placed "off center" for the same reason. By changing speed, big changes in the effectiveness of agitation can be obtained. The effectiveness of an impeller varies with the third power of the speed. Hence an increase of ten per cent in speed will increase the agitation as much as 30 to 40 per cent.

Agitators Have Various Designs

Some processes involve materials that have a propensity to stick to or build up on the vessel walls. A scraper then is used which may have its bearings on the agitator shaft as in *Fig.* 9. A bottom bearing for the shaft then becomes necessary. This vessel has a capacity of 1000 gallons using a speed of 12 revolutions per minute for the scraper and 90 for the turbine agitator. The scraper plates are alternately spaced on opposite sides of the assembly to cover entirely the inside surfaces of both the wall and bottom. Each plate acts as a leaf spring and is tensioned by an adjustable bolt with locknut. This preloading causes the scraper to follow any irregularity in the wall, the separate plates preventing undue scraping force on isolated high spots. In a unit of this kind it is necessary to have a smooth weld seam to remove the possibilities of bumps and chatter.

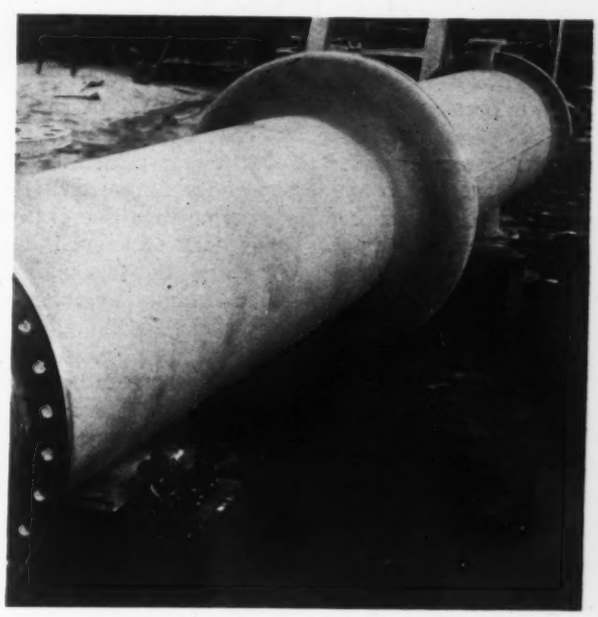
Heating may be accomplished by direct firing, circulating a heat-transferring medium through coils inside or outside the vessel or through a jacket surrounding the vessel, or electric heating using a system of strip heaters or induction coils. The last named method has advantages in that control is accurate, response is quick and heating is uniform throughout the charge. Direct firing is the least satisfactory because of poor control, fire hazards and long cooling cycles. Oil is satisfactory for a circulating medium where temperature requirements are moderate. Saturated steam provides increased temperatures but is limited to less than 350 degrees Fahr. because of the sharp increase in pressure beyond this point. Dowtherm is used for higher temperature, giving 750 degrees Fahr. at 135 pounds per square inch.

When heating is accomplished by circulating oil, steam or Dowtherm in a jacketed vessel, care must be exercised in the design of the jacket so that unequal expansion rates of the vessel and jacket do not cause undue stresses. Joining of the jacket, as in *Fig.* 6, by welding direct to the vessel is preferable to the previously recommended practice involving welding of a steel ring about the vessel and welding the jacket to this ring. Excessive stresses would be created because of uneven expansion in the joined members due to thick joint section. In *Fig.* 10 is shown a large expansion section in the jacket wall with the jacket welded to the flange ends of the vessel. Another method is shown in *Fig.* 6 for an enamel lining. The jacket is shaped at the upper end to conform with the vessel diameter and welded in such a manner as to keep the vessel as uniform as possible for the enameling process. Expansion is provided by a diaphragm at the bottom of the vessel around the bottom flange as shown.

Safety devices are necessary on all pressure vessels. Spring-loaded valves are used widely but, when employed, should be operated periodically to assure their ability to function. Rupture disks, however, are more generally used in corrosive atmospheres and are made of a material impervious to the action of the vessel's contents. These disks may be accurately calibrated to rupture at a given pressure.

Co-operation of the following companies for information and illustrations used in this article is gratefully acknowledged: Blaw-Knox Co., *Figs.* 4, 5, 7, 9 and 10; General Electric Co., *Fig.* 1; Glascote Products Inc., *Figs.* 6 and 8; The Pfaudler Co., *Fig.* 2; A. O. Smith Corp., *Fig.* 3.

Fig. 10—Jacketed vessel with expansion section to minimize stresses from unequal expansion



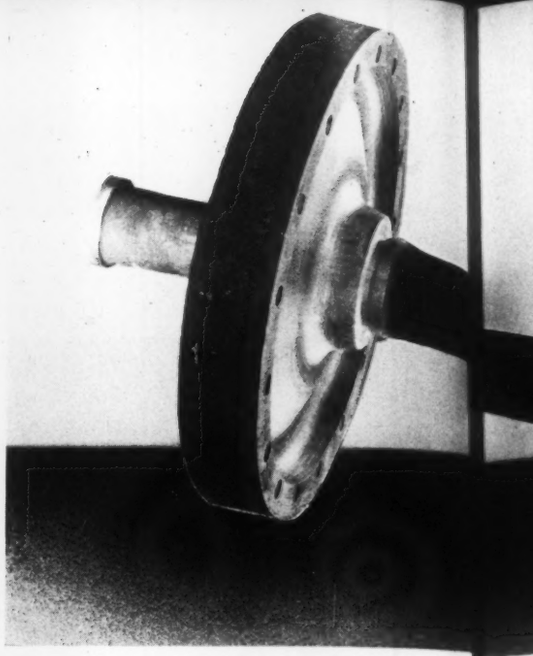


Fig. 1—Shrink-fit assembly of a railway axle and hub involves stresses due to fit, bending and twisting moments, and axial loading

By Joseph Marin
Pennsylvania State College

Designing Shrink-Fit Assemblies

Part I

SEVERAL types of assemblies used in design involve fits in which one of the parts is forced or shrunk onto a component part. Examples of press or shrink-fits are encountered in: Bushings, ball and roller bearings, motor armature spiders, built-up crankshafts, built-up guns, shaft couplings, hub and shafts, railway axles and flywheels.

Allowances or differences between diameters of the component parts, per inch of diameter, depend upon the type of fit and kind of application considered. Various recommendations for the allowance to be used with press and shrink-fits are given in handbooks and textbooks dealing with machine design[1]. An allowance of .001-inch per inch of diameter represents average practice for such work as crankshafts and crankpins where a tight press-fit is required. On the other hand, for such assemblies as armature spiders and flywheels, one-half this allowance may be sufficient. For shrink-fits, a greater allowance is often made although the value of .001-inch per inch should not be exceeded.

In the case of press-fits, the allowance to be used will depend upon the character of the material, the finish of the surface and the lubricant applied. The pressure required to make the press-fit will depend also upon the length and radial thickness of the hub. Practice regarding press-fits has been satisfactorily established by the Association of American Railroads[2]. This association specifies several conditions for mounting crank pins and axles in wheels. They recommend 6 to 10 tons per inch of axle diameter as the maximum pressing force for cast-iron wheels and 10 to 16 tons for steel wheels. A lubricant mixture is also recommended for press-fit assemblies. In *Fig.* 1 is shown a typical assembly.

Other constructional features of this problem might be considered in this article. The discussion, however, will be confined to a consideration of the stresses produced in press and shrink-fit assemblies.

A diagrammatic picture of a shrink-fit assembly is shown in *Fig.* 2, in which an outer member representing the hub is shrunk on the inner part corresponding to an axle. Pressure produced between these two units will not be constant throughout the length of the hub but will be greatest where the

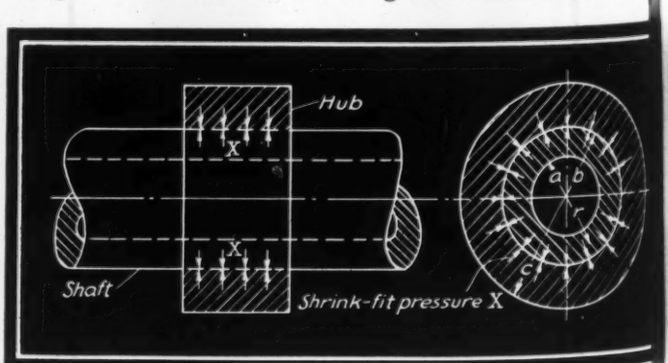
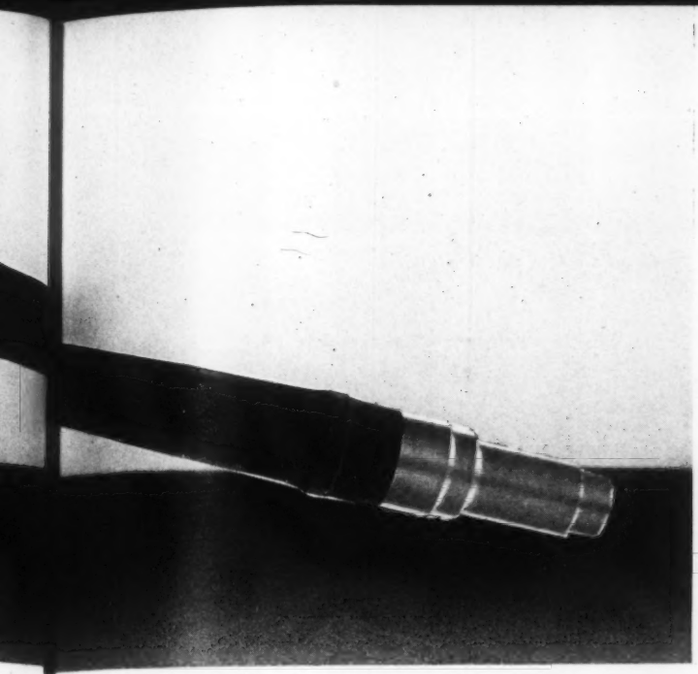


Fig. 2—Shrink-fit assembly of hub on a shaft

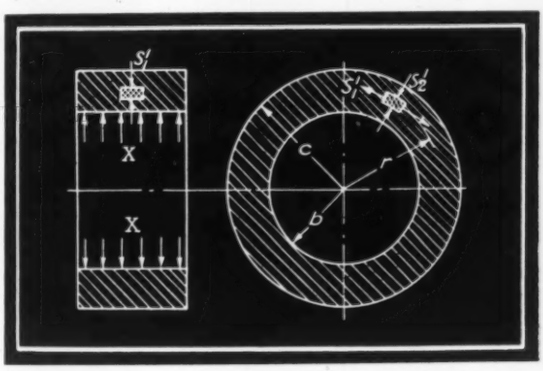
[1]See, for example, *Machinery's Handbook*—E. Oberg and F. D. Jones, Industrial Press, 10th Edition, 1940; and *Elements of Machine Design*—D. S. Kimball and J. H. Barr, John Wiley & Sons Inc., 1935.

[2]See *Manual of Standard and Recommended Practice*, Assoc. of American Railroads, Chicago, Illinois, Feb. 1937.



—Courtesy Timken Roller Bearing Co.

Fig. 3—Stresses from shrink-fit pressure on an element in hub



axle or inner unit projects beyond the hub or outer part. At this section there is a stress concentration, the magnitude of the pressure depending upon the shape of the bore in the hub. Neglecting the effect of this stress concentration, an expression for the shrink-fit pressure can be determined in terms of the fit allowance, dimensions of the assembly, and material constants. For the general case, as shown in *Fig.* 2, in which the hub and axle are of different materials, the shrink-fit pressure X in pounds per square inch is[3]

$$X=\frac{\delta}{\frac{1}{E_1}\left(\frac{c^2+b^2}{c^2-b^2}+m_1\right)+\frac{1}{E}\left(\frac{b^2+a^2}{b^2-a^2}-m\right)} \quad \ldots\ldots (1)$$

where δ is the press-fit allowance per inch of shaft diameter, $2b$; a, b and c are the radii as shown in *Fig.* 2; E_1 and E are the moduli of elasticity of the hub and shaft material, respectively; and m_1 and m are the values of Poisson's ratio for the hub and shaft materials, respectively. TABLE I gives the values of the shrink-fit pressure X for special cases of Equation 1.

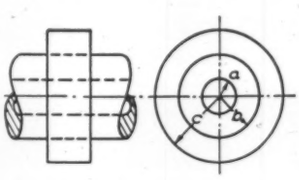
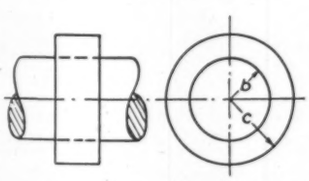
Knowing the shrink-fit allowance δ, TABLE I can be used to determine the shrink-fit pressure by substituting directly in one of the equations given. Stresses due to this pressure can now be obtained in terms of the pressure X by considering the hub as a thick-walled cylinder subject to internal pressure and by treating the shaft as a solid or hollow cylinder subject to external pressure[4]. For the hub, *Fig.* 2, the principal stresses at a radius r are

[3] See *Stress Analysis in Electrical Rotating Machinery*—M. Stone, *Transactions*, A.S.M.E., Vol. 50, Part I, Sept.-Dec., 1928, A.P.M.-50-16, Pages 57-79.

[4] For an analysis of these stresses see, for example, *Strength of Materials*—S. Timoshenko, Vol. 2, 1941.

TABLE I

Shrink-Fit Pressure Values

Type of Shrink-Fit Member	Material of Hub and Shaft	Shrink-Fit Pressure, X
Hub and Hollow Shaft 	Different Materials	$X=\frac{\delta}{\frac{1}{E_1}\left[\frac{c^2+b^2}{c^2-b^2}+m_1\right]+\frac{1}{E}\left[\frac{b^2+a^2}{b^2-a^2}-m\right]}$
	Same Materials	$X=\frac{E\delta(c^2-b^2)(b^2-a^2)}{2b^2(c^2-a^2)}$
Hub and Solid Shaft 	Different Materials	$X=\frac{\delta}{\frac{1}{E_1}\left(\frac{c^2+b^2}{c^2-b^2}+m_1\right)+\left(\frac{1-m}{E}\right)}$
	Same Materials	$X=\frac{E\delta(c^2-b^2)}{2c^2}$

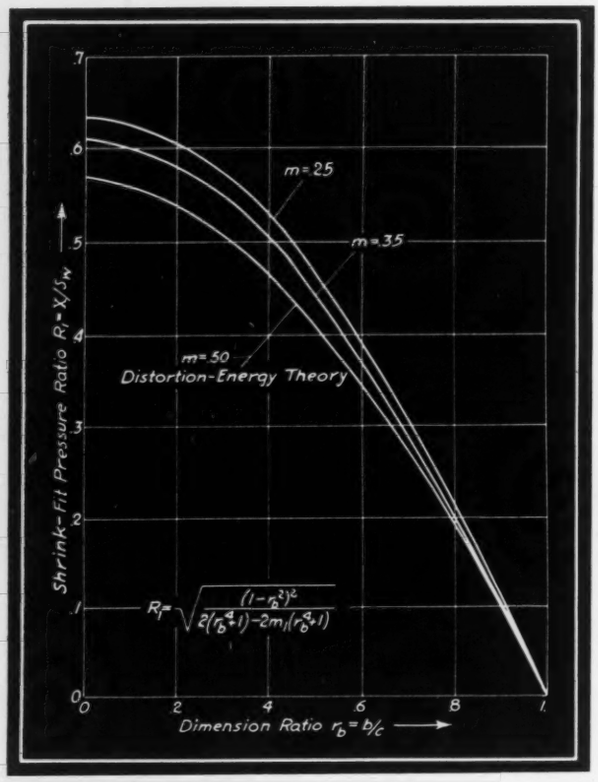


Fig. 4—Chart for determining hub diameter for various shaft diameters and pressure ratios

$$S_1' = \frac{b^2}{c^2-b^2}\left(1 - \frac{c}{r^2}\right)X \Bigg\}$$
$$S_2' = \frac{b^2}{c^2-b^2}\left(1 + \frac{c^2}{r^2}\right)X \Bigg\} \quad \ldots\ldots (2)$$

In a similar manner the stresses in hollow shaft, *Fig.* 2, can be shown to be

$$S_1' = -\frac{b^2}{b^2-a^2}\left(1 - \frac{a}{r^2}\right)X \Bigg\}$$
$$S_2' = -\frac{b^2}{b^2-a^2}\left(1 + \frac{a^2}{r^2}\right)X \Bigg\} \quad \ldots\ldots (3)$$

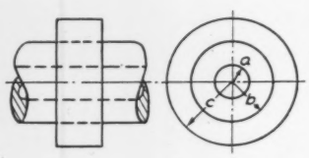
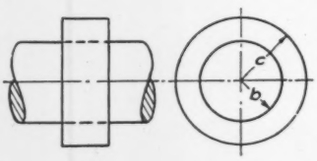
In addition to the stresses produced by the shrink-fit pressure there may also be stresses from inertia forces, produced by rotation, as in railway axles or shafting. In some applications, stresses may be introduced due to axial loading and bending moments as, for example, in railway axles[5]. There may also be a twisting moment which will influence the stress distribution in both the hub and shaft.

One effect of the inertia forces is to change the value of the shrink-fit pressure if the rates of speed are appreciable. This is because the hub has greater radial deformation than the shaft at the surface of contact. The difference in deformation is produced by the centrifugal forces and is equivalent

[5] An excellent analysis of the forces produced in railway axles is given by R. Eksergian in "The Design of Railway Axles and Locomotive Crank Pins", *Transactions*, A.S.M.E., Vol. 60, 1938, RR 60-1, Pages 153-189.

TABLE II

Decrease in Fit Between Hub and Shaft from Inertia Forces

Type of Shrink-Fit Member	Material of Hub and Shaft	Decrease in Shrink-Fit Allowance δ per Inch of Shaft; Diameter $= \delta_1$
Hub and Hollow Shaft 	Different Materials	$\delta_1 = \frac{v_1^2}{64g}\left\{\frac{\gamma_1}{E_1}\left[(3+m_1)+(1-m_1)\frac{b^2}{c^2}\right]-\frac{\gamma}{E}\left[(3+m)\frac{a^2}{c^2}+(1-m)\frac{b^2}{c^2}\right]\right\}$
	Same Materials	$\delta_1 = \frac{v_1^2\gamma}{64g}\left(\frac{3+m}{E}\right)\left(1-\frac{a^2}{c^2}\right)$
Hub and Solid Shaft 	Different Materials	$\delta_1 = \frac{v_1^2}{64g}\left\{\frac{\gamma_1}{E_1}\left[(3+m_1)+(1-m_1)\frac{b^2}{c^2}\right]-\frac{\gamma}{E}(1-m)\frac{b^2}{c^2}\right\}$
	Same Materials	$\delta_1 = \frac{v_1^2\gamma}{64g}\left(\frac{3+m}{E}\right)$

to a decrease in the shrink-fit allowance. For a hub and hollow shaft of different materials the decrease in the allowance becomes

$$\delta_1 = \frac{v_1^2}{64g}\left\{\frac{\gamma_1}{E_1}\left[3+m_1+(1-m_1)\frac{b^2}{c^2}\right]-\right.$$

$$\left.\frac{\gamma}{E}\left[(3+m)\frac{a^2}{c^2}+(1-m)\frac{b^2}{c^2}\right]\right\} \quad \ldots\ldots\ldots\ldots (4)$$

where v_1 is the linear velocity of outside diameter of the hub; E_1 and E are the modulus of elasticity of hub and shaft, respectively; γ_1 and γ are weight per unit volume of hub and shaft material, respectively; and g is the acceleration of gravity. TABLE II gives the expression for the decrease in shrink-fit allowance due to inertia forces for special cases of Equation 4. In cases where inertia effects are important it is desirable to correct for the shrink-fit stresses by determining the correction to the shrink-fit pressure as given by Equation 4.

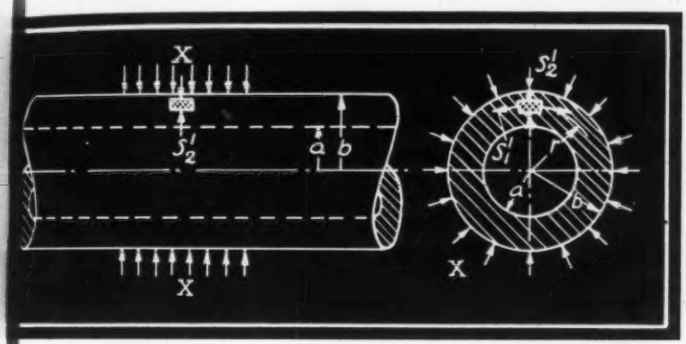


Fig. 5—Stresses on shaft from pressure of hub

Service conditions may also influence the holding ability of assemblies. In addition to the effect of centrifugal forces, holding ability of hub and shafts with respect to axial loading and torsional moments must also be considered. Furthermore, it is sometimes necessary to consider the influence on the holding capacity of transverse loading, producing bending and transverse shear. Some test data and semi-empirical formulas are available for obtaining design data on this problem[6]. Shape of the axle end and the wheel bore, effects of prestressing, lubricant used, method of assembly, surface finish, repeated assembling of parts, and heat treatment of the material also are factors affecting holding ability.

It is apparent therefore that many factors must be considered in the design of shrink-fit assemblies. One primary factor that has not been adequately treated, is the effect of the combined state of stress on the design of shrink-fit assemblies. This will be covered in the following. The analysis deals only with static loads but considers various types of loadings.

[6] This problem is discussed by O. J. Horger and C. W. Nelson, "Design of Press and Shrink-Fitted Assemblies", *Transactions*, A.S.M.E., Vol. 59, 1937, A.P.M., Pages 183-187.

BIAXIAL STRESSES: *Example 1 — Shrink-Fit Stresses Only*—In applications in which shrink-fit stresses are predominant and in which other stresses can be neglected, the required size of shaft and hub can easily be calculated. For the hub, the stresses produced at a radius r *Fig.* 3, is

$$U = \frac{1}{2E_1}(S_1^2 - 2m_1S_1S_2 + S_2^2) \quad \ldots\ldots\ldots\ldots (5)$$

Placing the values of the stresses from Equations 2 for the stresses S_1 and S_2 in Equation 5, the strain energy for the element at a distance r from the center is

$$U = \frac{1}{2E_1}\left(\frac{b^2}{c^2-b^2}\right)^2\left[2(1-m_1)+2\frac{c}{r^4}(1+m_1)\right] \quad \ldots\ldots (a)$$

By inspection, U is a maximum when r is a minimum, or for $r=b$. That is,

$$U_{max} = \frac{1}{2E_1}\left(\frac{b^2}{c^2-b^2}\right)^2\left[2(1-m_1)+2(1+m_1)\frac{c^4}{b^4}\right] \quad \ldots (b)$$

The required value of c for a given value of b is determined by placing U_{max} equal to its allowable value $S_w^2/2E_1$ where S_w is the allowable stress.

Doing this,

$$\frac{X}{S_w} = \sqrt{\frac{(c^2-b^2)^2}{2(b^4+c^4)-2m_1(b^4-c^4)}} \quad \ldots\ldots\ldots\ldots (c)$$

or

$$R_1 = \sqrt{\frac{(1-r_b^2)^2}{2(r_b^4+1)-2m_1(r_b^4-1)}} \quad \ldots\ldots\ldots\ldots (6)$$

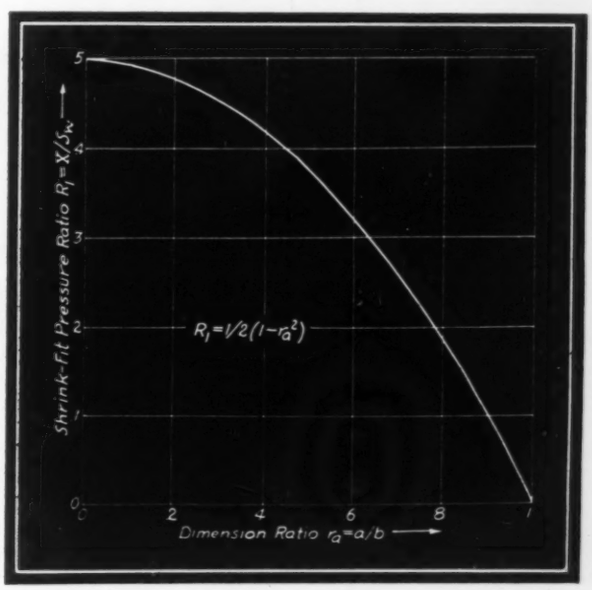


Fig. 6—Variations in shrink-fit pressure with dimensions

where $R_1 = X/S_w$ = the shrink-fit pressure-stress ratio, and $r_b = b/c$ the dimension ratio.

From Equation 6 the required value of the dimension ratio and, hence, of c can be determined by substituting for m_1 and R_1. The fit-stress ratio R_1 can be determined by Equation 1 if a value of c is assumed. After c is determined from Equation 6, the corrected value of X can be found and two or three trials will be sufficient to determine the radius c accurately. As an aid to calculating the dimension c, a design chart is shown in *Fig.* 4 representing the variation between the shrink-fit ratio R_1 and the dimension ratio r_b. Plots are shown for values of Poisson's ratio equal to .25, .35 and .5. These diagrams represent the variations in r_b as defined by Equation 6. Values for $m = .5$ are shown since this gives the recommended values using the distortion energy theory and represents

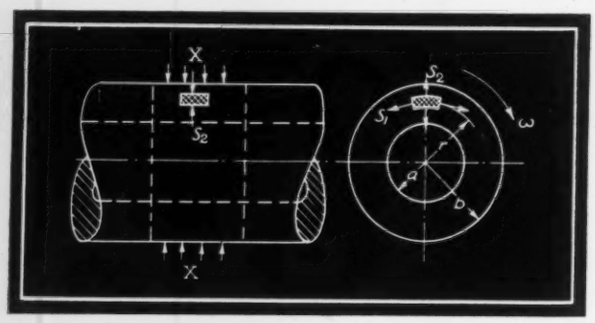


Fig. 7—Resultant stresses on an element of shaft due to centrifugal force and shrink-fit pressure

a good approximation for two-dimensional stresses and for ductile materials.

For the shaft, the stresses produced by the shrink-fit pressure are determined completely by Equation 3. To evaluate the required outer radius b for a particular value of radius a, the method used for the hub can be employed. Thus, for an element at a distance r, *Fig.* 5, the strain energy can be determined by Equation 5 provided m_1 and E_1 are replaced by m and E—the value of Poisson's ratio and modulus of elasticity, respectively, for the material used in the shaft. Substituting the values of the stresses from Equations 3 in Equation 5, the strain energy for the element is shown to be

$$U = \frac{1}{2E}\left(\frac{b^2}{b^2-a^2}\right)\left[2(1-m)+2\frac{a^4}{r^4}(1+m)\right] \quad \ldots\ldots (d)$$

Maximum value of U by inspection of Equation d is found to be for the minimum value of r, that is, for $r = a$. Using this value of r, maximum strain energy becomes

$$U_{max} = \frac{2}{E}\left(\frac{b^2}{b^2-a^2}\right)^2 \quad \ldots\ldots (e)$$

Equating this value of U to its allowable value $S_w^2/2E$, the shrink-fit ratio, X/S_w is

$$\frac{X}{S_w} = \frac{1}{2}\left(1-\frac{a^2}{b^2}\right) \quad \ldots\ldots (f)$$

or

$$R_1 = \frac{1}{2}(1-r_a^2) \quad \ldots\ldots (7)$$

where R_1 is the shrink-fit ratio X/S_w and r_a is the dimension ratio, a/b.

The required outer radius b for a known inner radius a can be found by a trial procedure as explained for the foregoing analysis of the hub. That is, a value of b is assumed and by Equation 1 the shrink-fit pressure X is calculated. With X and S_w known, the ratio R_1 in Equation 7 is known and by this equation r_a and hence b can be calculated. With this new value of b, a corrected value of the shrink-fit pressure X can be determined by Equation 1 and the procedure repeated until the two successive values of b differ only slightly. The variation in the value of the shrink-fit pressure with variation in dimensions is shown in *Fig.* 6. This diagram represents a plot of Equation 7 showing the variation in the dimension ratio r_a and hence the radius b for a variation in the shrink-fit pressure ratio $R_1 = X/S_w$. It is of interest to note that Equation f does not involve Poisson's ratio m. This is because at $r = a$ there is only one stress acting and there is then no combined stress effect.

Example 2—Shrink-Fit and Inertia Stresses—When a hub and shaft assembly is rotating at high speeds it is necessary to consider the effects of the centrifugal forces. One effect which is discussed in the foregoing is the influence of these forces on the shrink-fit pressure. The decrease in this pressure due to the centrifugal forces can be determined from the equivalent decrease in the fit allowance produced by these forces. This can be determined by using Equation 4, giving the decrease in shrink-fit allowance.

Another effect of centrifugal forces is to introduce inertia stresses which can be directly superimposed on the shrink-fit stresses to obtain the resultant stresses. For the shaft or inner cylinder, the inertia stresses for an element at a distance r can be shown to be

$$\left.\begin{aligned} S_1'' &= B\left(1-\frac{a^2}{b^2}-\frac{r^2}{b^2}-\frac{a^2}{r^2}\right) \\ S_2'' &= B\left(1+\frac{a^2}{b^2}-\frac{Dr^2}{b^2}+\frac{a^2}{r^2}\right) \end{aligned}\right\} \quad \ldots\ldots (8)$$

where $B = \gamma v^2(3+m)/8g$, $D = (1+3m)/(3+m)$ and v = the velocity at the outer radius b of the shaft.

Superimposing the stress values from Equations 3 and 8, the resultant stresses for an element at

a distance r, *Fig.* 7, due to the shrink-fit pressure and centrifugal forces are

$$\left.\begin{aligned} S_1 &= \left(B - \frac{Ba^2}{b^2} - A\right) - \frac{Br^2}{b^2} + \frac{a^2}{r^2}(A-B) \\ S_2 &= \left(B + \frac{Ba^2}{b^2} - A\right) - \frac{BDr^2}{b^2} - \frac{a^2}{r^2}(A-B) \end{aligned}\right\} \quad \ldots (g)$$

where $A = Xb^2/(b^2-a^2)$. The required radius b can be determined by substituting the stress values as given in Equation g in Equation 5 and finding the element or value of r for which U is a maximum.

Considering the case in which the shaft is solid, Equation g can be used for determining the stresses by placing $a=0$. These stress values are

$$\left.\begin{aligned} S_1 &= (B-A) - \frac{Br^2}{b^2} \\ S_2 &= (B-A) - \frac{DBr^2}{b^2} \end{aligned}\right\} \quad \ldots (h)$$

Since this is a problem in two-dimensional stress, the distortion energy theory of failure is a good approximation for ductile materials. This theory states that the distortion energy for the element at a distance r is

$$V = c_1(S_1^2 - S_1S_2 + S_2^2) \quad \ldots (i)$$

Placing the values of S_1 and S_2 from Equation h in Equation i,

$$V = c_1\left[(B-A)^2 + (1-D+D^2)\left(\frac{Br^2}{b^2}\right)^2 - (1+D)(B-A)\left(\frac{Br^2}{b^2}\right)\right] \quad \ldots (j)$$

By calculus, the maximum value of V is for $dV/dr=0$. That is,

$$4(1-D+D^2)\frac{B^2r^3}{b^4} - 2(1+D)(B-A)\frac{Br}{b^2} = 0$$

or

$$r=0 \text{ and } r = b\sqrt{\frac{1}{2}\left(\frac{1+D}{1-D+D^2}\right)\left(\frac{B-A}{B}\right)} \quad \ldots (k)$$

Placing the values of r from Equation k in Equation j, the possible maximum values of V are

$$V'_{max} = V_{r=o} = c_1(B-A)^2 \quad \ldots (l)$$

and

$$V''_{max} = c_1\left[(B-A)^2 + \frac{(1+D)^2}{4(1-D+D^2)}(B-A)^2 - \frac{1}{2}\frac{(1+D)^2}{(1-D+D^2)}(B-A)^2\right] \quad \ldots (m)$$

A comparison of the values of the distortion energy in Equations l and m for all possible values of D show that V'_{max}, as given by Equation l, is the greater of the two values. Considering also the value of V for $r=b$, the value of V as given by Equation l is still a maximum. Equating the distortion energy in Equation l to the allowable value $c_1S_w^2$,

$$(B-A)^2 = S_w^2 \quad \ldots (n)$$

Replacing values of B and A in terms of the shrink-fit pressure X and speed v, since $B = \gamma v^2(3+m)/8g$ and $A = Xb^2/(b^2-a^2) = X$, then

$$\left[\frac{\gamma v^2}{8g}(3+m) - X\right]^2 = S_w^2 \quad \ldots (o)$$

Noting that $bv=\omega$ where ω is the angular velocity of the shaft, Equation o can be solved for the speed. That is,

$$\omega = \sqrt{\frac{8g}{\gamma b^2}}\sqrt{\frac{1}{3+m}}\sqrt{R_1+1} \quad \ldots (9)$$

where $R_1 = X/S_w$ = the shrink-fit pressure ratio.

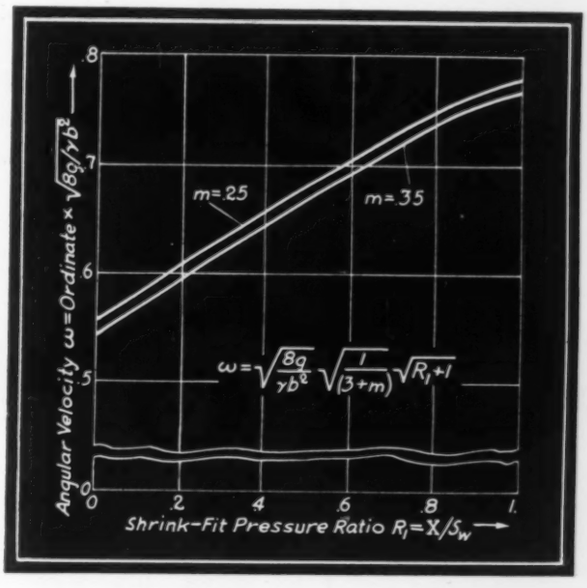


Fig. 8—Effect of pressure ratio on angular velocity

Two plots of Equation 9 for representative values of Poisson's ratio are shown in *Fig.* 8. For a particular value of the shrink-fit pressure, as represented by the co-ordinate R_1, the allowable speed is proportional to the ordinate to the curve. The ordinate multiplied by $(8g/\gamma b^2)^{1/2}$ then gives the allowable speed in radians per second. This can be transferred easily to revolutions per minute.

Effects of twisting and bending moments and axial loading upon assemblies will be discussed in the second part of this article, to be published next month. Also, selection of shaft diameters for these combined stresses will be treated.

Fig. 1—Internal grooves in shells for rubber marine bearings are milled in after casting. Vulcanized rubber-to-bronze strips are installed in the grooves as illustrated

By
Kenneth D. Moslander

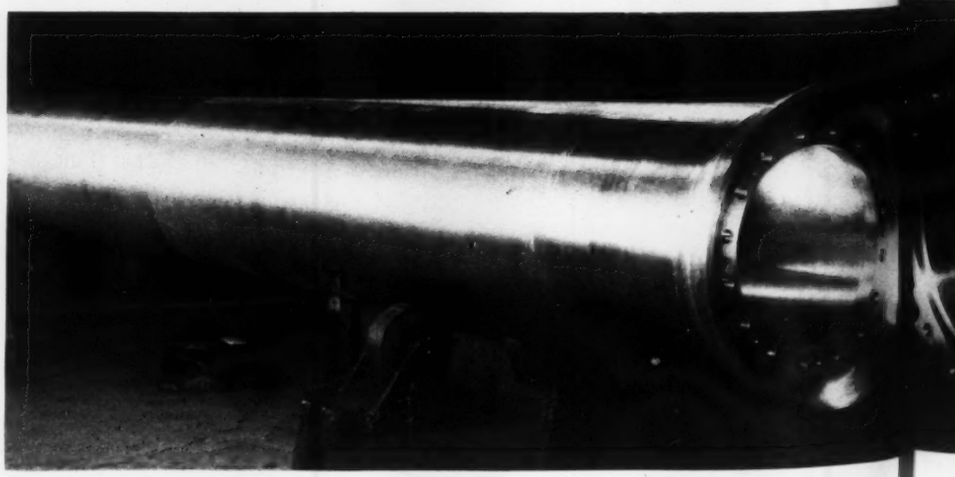
Does Centrifugal Castin

RESPONSIBILITY for smooth and rapid production is vested originally in the designer. His background of knowledge and experience enables him to take advantage in his designs of alternative manufacturing processes. Centrifugal casting, as one of the fabricating processes available to the engineer, is perhaps too often overlooked as a method of producing machine parts.

Necessity for the utilization of all existing capacity makes it imperative that the designer recall the advantages and limitations of the centrifugal casting process so that he may relieve to some extent the pressure on other overloaded facilities. For this reason the various design considerations germane to the process are discussed in the following, as are the several alloys adaptable to the process, and their physical properties. It is believed that with this information at his finger tips the designer can appraise the possibilities of having his machine components made by this process. Once such a possibility is established, the centrifugal casting producer will be of inestimable assistance in ironing out the final details of design and material specification for maximum speed and economy.

Many of the design limitations are self-evident from a general understanding of the process. Broadly, the process consists of rotating a sand-lined or permanent metal mold at speeds ranging from 600 to 2000 revolutions per minute depending upon the diameter, weight and alloy to be used. During rotation molten metal is introduced into

Fig. 2—Right end flange of large cylinder for the chemical industry is welded in place after casting



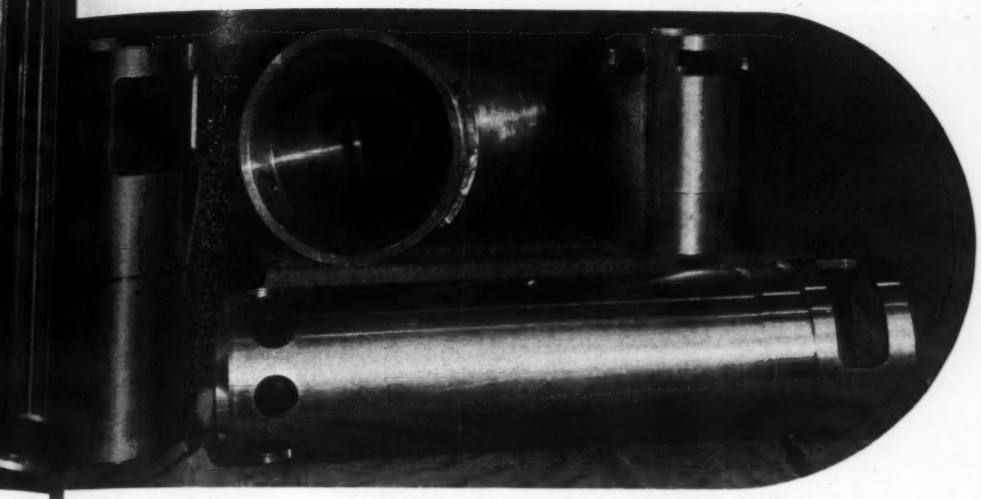


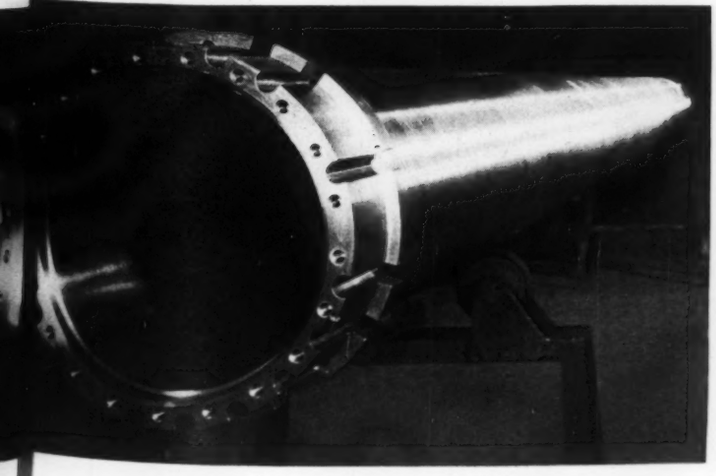
Fig. 4—Ports in the walls of cylinder liners are machined. For small ports where dynamic unbalance is of little importance these ports may be cored

tiOffer the Alternative?

the mold. As the metal is forced against the walls of the mold by centrifugal force it solidifies, conforming to the mold shape on its outer surface.

It is therefore apparent that the basic shape produced by this process is a tube, either thin or thick walled. Gear blanks, cylinder liners, pipes, brake drums, bearings, rolls, annular rings, valves, etc., fall in this classification and lend themselves to fabrication by the centrifugal casting process, but the hollow bore of such castings must be a uniform cylinder. It may, of course, be machined afterwards with counter bores, shoulders or internally extending flanges. The external surface need not be cylindrical. Hexagons, squares or any other geometrically symmetrical shape may be obtained.

Fig. 3—Opposite end of cylinder illustrated in Fig. 2 is cast as a solid collar integral with cylinder. Machining operations are performed after casting



Outwardly extending flanges, as illustrated by the segmental rubber marine bearing in *Fig.* 1, are obtained easily. Because of the desirability of not having too radical changes in cross section which might result in internal stresses in the final part due to the unequal cooling, such flanges should not be much thicker than the wall of the tube. The internal longitudinal slots in these bearings, which hold rubber-surfaced bronze bearing strips, are milled in the surface after casting. External flanges or other protuberances, particularly on fairly long castings, should be located only on one end. If such flanges were located on both ends, they would each act as an anchor and prevent the normal shrinkage of the casting during the solidification of the metal. This would set up stresses in the walls of the tube and might result in cracking.

One method of circumventing this design limitation is illustrated by *Fig.* 2. In this cylinder for the chemical industry, flanges were necessary on

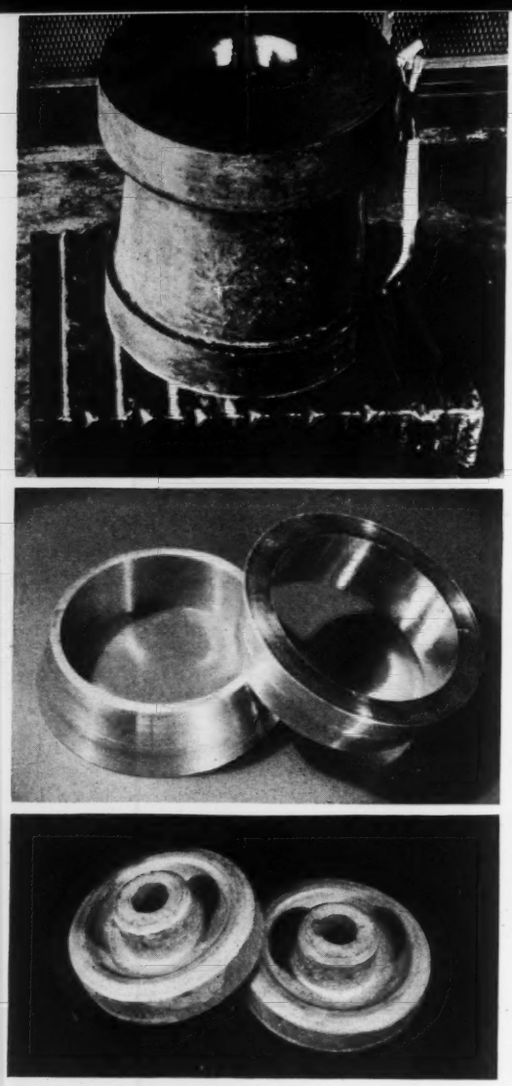


Fig. 5—Versatility of centrifugal casting process is illustrated by parts shown above

both ends. To accommodate the design to the casting process the flange on the right end was cast separately and then fastened to the main body of the cylinder by welding. Illustrated in *Fig.* 3 is the other end of this cast cylinder. The shoulder on this end is cast with a regular cylindrical surface. After boring the holes the surface is turned down to the desired profile and dimension. If only a nominal amount of metal is to be removed to produce the desired end contours as in this flange, it is usually economical to machine the shape rather than to cast it. Core work, special molds, shrinkage problems, etc., ordinarily augment the cost of the finished part sufficiently to justify considerable machining.

Comparatively high speeds of rotation combined with the large masses ordinarily cast impose the additional requirement that the parts be dynamically balanced. Although small amounts of unbalance are sometimes tolerable such as, for example, small ports in cylinder liners, any considerable unbalance will so overload the bearings and structural members of the casting machinery as to preclude such a condition. Hence, when fairly large holes are required in the casting in such a location that they would contribute to the dynamic unbalance of the part, they are machined afterward, the part being cast solid. Examples of such liners are shown in *Fig.* 4.

Machining Facilitates Inspection

In connection with such finish machining operations, as well as those that may be desirable in order to remove the rough cast surface, it is preferable to have the centrifugal casting producers perform the machining operations. By so doing, the engineer's company derives the advantage of the cost of the scrap metal which, because of quality control systems, is almost invariably worth more to the castings producer than it is to the customer's plant. Also, in addition to appreciable savings in freight rates due to decreased weight of the part, specifying that the castings producer perform the machining operation enables him to carry out a better program of inspection than otherwise would be possible.

For ordinary machined parts, the size limitations of the centrifugal casting process are usually more than adequate. Diameters of parts may approach 50 inches, while in length 300 and more is possible.

Of importance to the designer in comparing the cost of this method of producing parts with other methods is the fact that usually small allowances for finishing are required. This allowance may amount to as little as 1/16-inch in small diameter castings up to about ¼-inch on the radius of the outside surface of the larger diameter castings. This range holds substantially even for wall thicknesses as little as ¼-inch.

In the case of inside surfaces of cylindrical parts

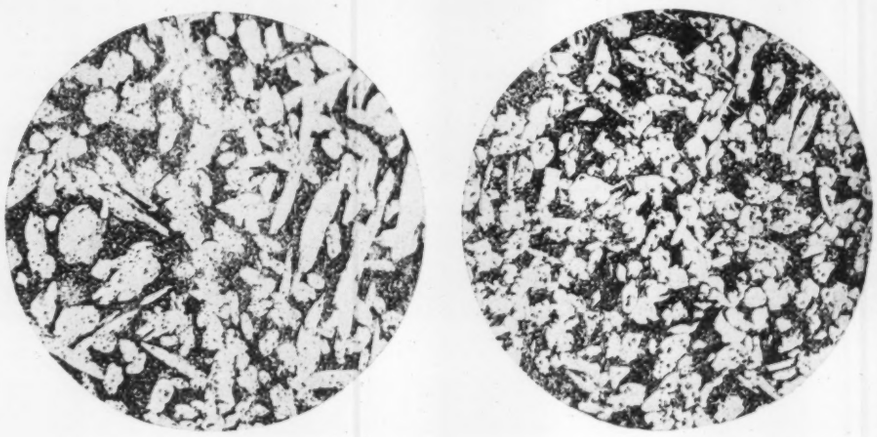


Fig. 6—Aluminum bronze centrifugally cast (extreme right) shows smaller grains with more uniform distribution than sand casting in adjacent micrograph

the finish allowance is somewhat greater. This is attributable to the fact that the material adjacent to the inside surface of the cylinder contains all or practically all of the imperfections and impurities in the casting, due to such imperfections or impurities being of a lower density than the cast metal. Under the influence of centrifugal force the heavier material is forced to the farthest point from the center of rotation of the mold, thus leaving slag inclusions, oxides, etc., embedded in the inner wall and hence necessitating their removal by subsequent machining operations. The centrifugal effect also results in higher physical properties, better crystalline orientation, smaller grain size and slightly increased density of the finished part. Microphotographs, *Fig.* 6, show clearly the improvement in structure.

Composition and Physical Properties of Casting Alloys

Alloying Elements and Physical Properties	Specification					
	Navy 46M6f	Gray Iron	Ni-Resist	Manganese Bronze	Copper Silicon	Monel
Copper	86–89	.....	5–7	55–60	90–96	23
Tin	7.5–11	.....	.....	1.5 max.	2.0 max.	.....
Zinc	1.5–4.5	.....	.....	38–42	5.0 max.	.....
Lead	.3 max.	.....	.....	.20 max.	.....	.....
Nickel	.75 max.	.....	12–15	.....	.....	60
Manganese	.....	.90–1.20	1.0–1.5	3.5 max.	1.5 max.	3.5
Iron	.10 max.	Balance	Balance	.4-2.0	2.5 max.	3.5
Silicon	.....	1.80–2.20	1.25–2.00	.....	1–5	.....
Carbon	.....	3.20–3.60	2.75–3.10	.....	.....	2
Aluminum	.....	.....	.....	1.5 max.	.....	.5
Chromium	.....	.....	1.5–4	.....	.....	.....
Tensile Strength (psi)	44,000–50,000	28,000 min.	20,000–25,000	65,000–110,000	45,000–50,000	65,000
Elongation (% in 2 in.)	25-35	.....	.....	15–30	15–25	25
Brinell hardness	60–80	175–190	120–180	70–250	50–130	130

Since solidification begins where the metal makes contact with the mold, grain growth in a still casting starts from both inside and outside surfaces, but only from the outside of a centrifugal casting. In the latter case there is no meeting of two separate dendritic grain growths where weakness might occur due to segregation of impurities, *Fig.* 7. Resulting from improved structure, the strength of centrifugally cast parts may be as much as 20 per cent greater than that of similar parts still cast; elongation may be as much as 30 per cent greater, and hardness is increased slightly.

It has been mentioned previously that dynamically balanced parts are best adapted to the centrifugal casting process. In subsequent discussion it has been assumed that all plane cross sections perpendicular to the axis of rotation of the piece were identical. This is, of course, not a prerequisite of dynamic balance but naturally such balance results when the axis of rotation of the mold lies in a horizontal plane. In some standard processes, however, this axis lies in a vertical plane and in this case the designer is afforded a certain latitude

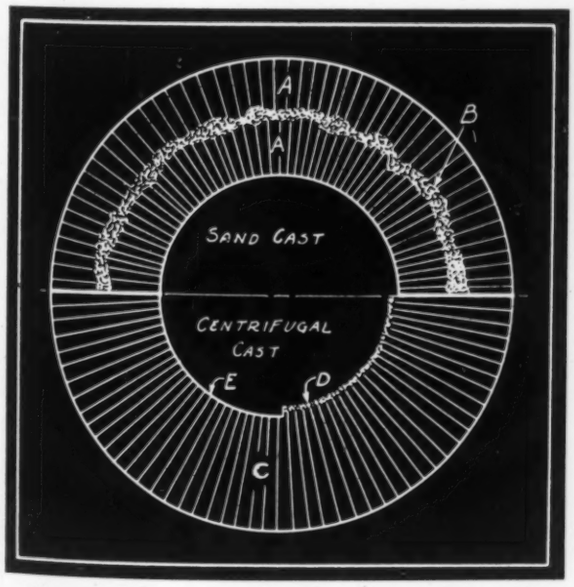


Fig. 7—Cooling in sand casting starts from inside and outside. Centrifugal casting solidifies inwardly from the outside, providing better crystalline orientation

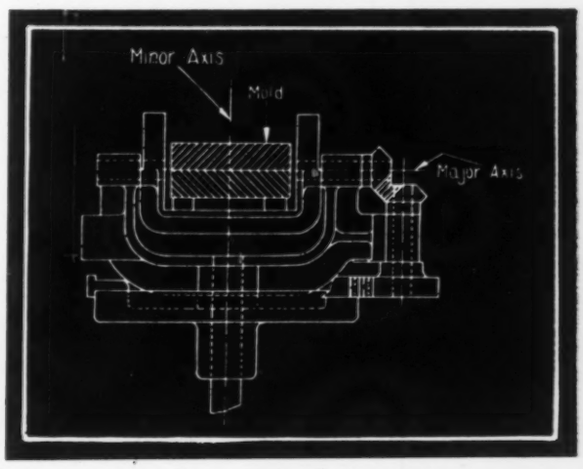


Fig. 8—Rotation of a mold about two mutually perpendicular axes is used to produce hollow, unsymmetrical castings by the centrifugal process

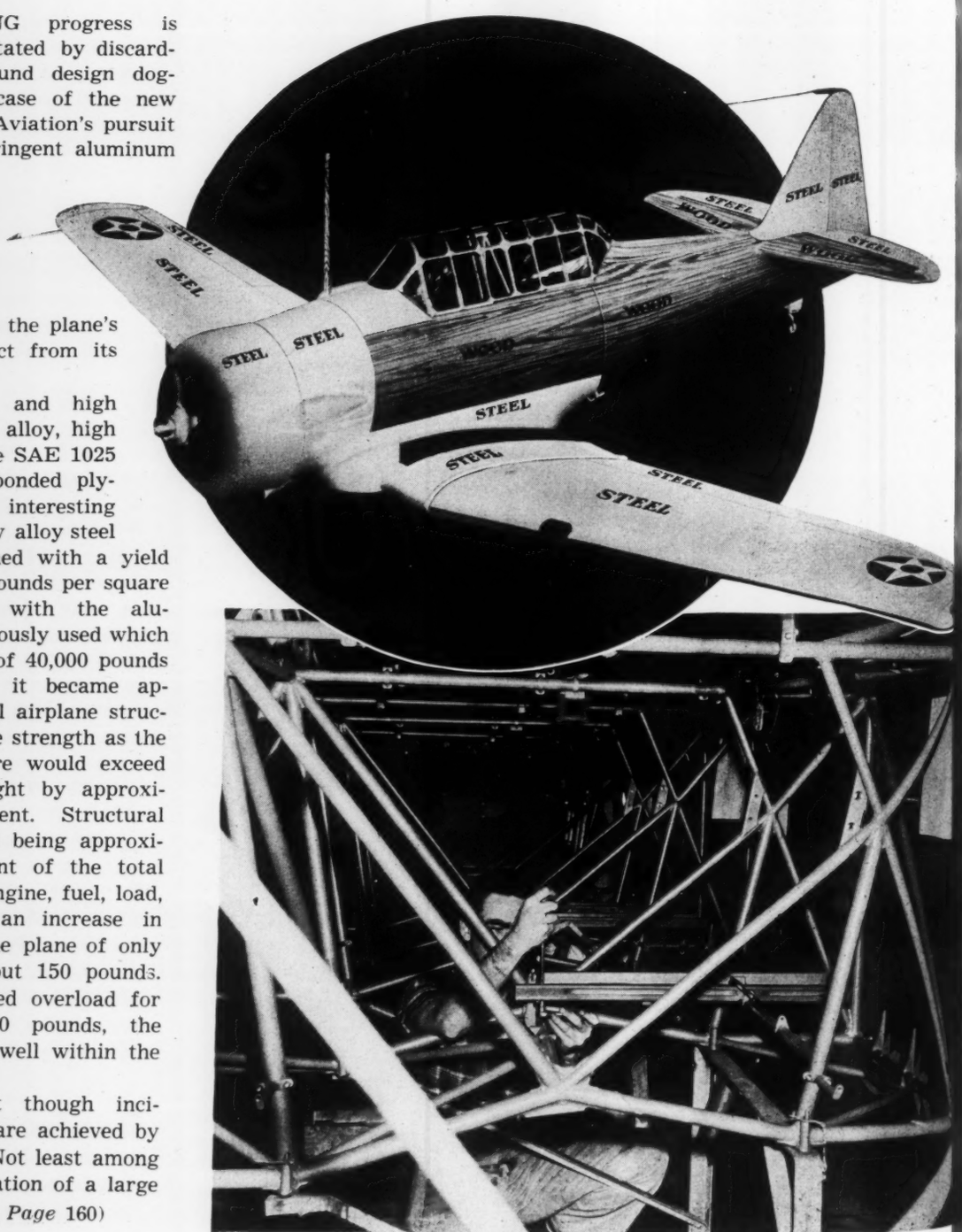
in the design of the internal surface of the part. Slightly concave or convex annular disks are possible by this method as are also minor irregularities in wall thickness, particularly of heavy-walled cylinders.

Also of considerable interest in that it represents future potential commercial application of the process is the production of irregularly shaped machine parts by rotating the mold about more than one axis. Some work of an experimental nature has already been done in this phase of centrifugal casting utilizing equipment sketched

(*Concluded on Page* 102)

Steel and Wood Replace Aluminum

ENGINEERING progress is often facilitated by discarding hide-bound design dogmas, as in the case of the new North American Aviation's pursuit trainer plane. Stringent aluminum supply conditions led engineers to investigate possible substitutes which would not add materially to the plane's weight nor detract from its performance.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Calculating Machine Tool Power Requirements

By O. W. Boston
University of Michigan

FORCES developed by the cutter of a machine tool and the power requirements of the motor in metal cutting operations are of importance for several reasons, including: Selection of the proper size of motor to be employed on the machine tool; design of the power transmission from the motor to the cutting tool; design of the feed transmission mechanism; determination of stresses and deflections in the frame and various parts of the machine tool; design of jigs, fixtures, and special tools for holding the work during the machining operation; and the selection of the proper size of cutting tools.

In this discussion the power requirements have been obtained for various types of metal cutting operations such as turning, drilling, milling, planing, etc., and general conclusions may be drawn that the horsepower at the cutter divided by the cubic inches of metal cut per minute, called net horsepower per cubic inch per minute, has a value of approximately 1 for steel, and about .6 for cast-iron. The gross horsepower per cubic inch of metal cut per minute, that is, considering the power developed by the motor, will average about 2.5 for steel and 1.2 for cast iron.

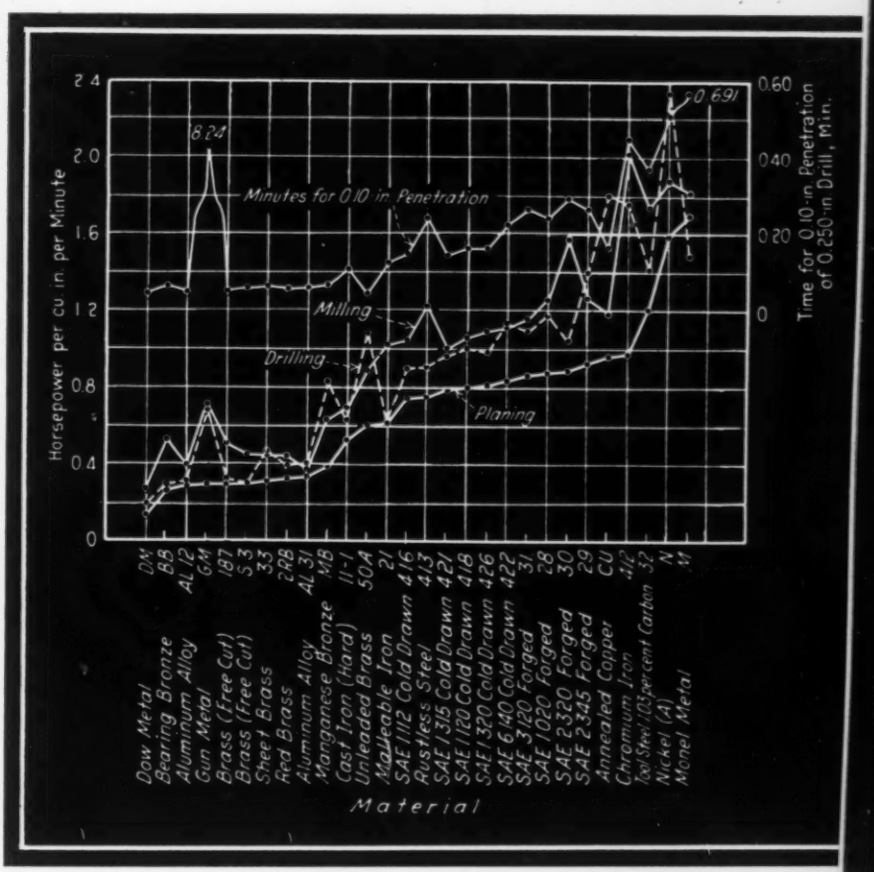


Fig. 1—Net horsepower required per cubic inch of metal cut per minute in drilling, milling and planing

DESIGN of machine tools rests on a sound knowledge of the forces developed between the cutter and the work. This article, abstracted from Professor Boston's paper presented at this year's Westinghouse Forum, highlights recent results of the author's well-known series of cutting tool investigations. Because production for victory depends largely on machine tools and their cutting capacities, the type of information presented is of particular value at this time

These values will vary over a considerable range, however, depending upon the specific operation performed, the machine tool, the shape of the tool, the cutting speed, and the particular metal being machined. As an illustration, *Fig.* 1 presents values of net horsepower per cubic inch per minute for drilling, milling, and planing a wide range of

TABLE I

Tool Life and Power Tests*

Test No.	Tool	Feed (in.)	Depth of Cut (in.)	Cutting Speed (fpm)	Life (min)	Volume Removed (cu in./min)	Input Power Gross (hp)	Input Power Tare (hp)	Input Power Net (hp)	Net Hp (per cu in. per min)	Tang. Force (lb)
1	High-Speed Steel[1]	.010	.05	150	18.02	.90	2.28	1.47	.81	.90	179
2	Carbon Tool Steel[2]	.010	.05	55	2.40	.33	1.81	1.41	.40	1.21	250
3	Carboloy 78B[3]	.010	.05	1000	.....	6.00	10.60	4.35	6.25	1.04	206
4	Carboloy 78B[3]	.015	.05	300	.....	2.25	3.82	1.61	2.21	1.03	243
5	Carboloy 78B[3]	.030	.05	300	.....	4.50	5.52	1.61	3.91	.87	430
6	Carboloy 78B[3]	.060	.05	300	.....	9.00	9.37	1.61	7.76	.86	855
7	Carboloy 78B[3]	.010	.25	300	.....	9.00	9.10	1.61	7.39	.82	812
8	Carboloy 78B[3]	.015	...	290	.....	13.00	13.00	1.61	11.39	.87	1300

*Turning SAE 3140 steel normalized and annealed (220 Brinell).

[1]Tool signature 8, 22, 6, 6, 6, 15, 3/64 (8-deg. back rake, 22-deg. side rake, 6-deg. side relief, 6-deg. end relief, 6-deg. end cutting-edge angle, 15-deg. side cutting-edge angle, 3/64-in. nose radius).

[2]Tool signature 8, 14, 6, 6, 6, 15, 3/64.

[3]Tool signature 0, 8, 7, 7, 8, 0, 1/32.

metals. For magnesium (Dowmetal), the horsepower per cubic inch of metal planed per minute is .12. The value increases through a wide variety of nonferrous metals up to about .6 for cast iron and malleable cast iron, and then ranges from .75 to .92 for a wide range of steels, is just below 1 for annealed copper, but increases to a maximum value of 1.7 for monel metal. Similar values are given for specific conditions of drilling and milling on the same chart. These values, however, are uniformly

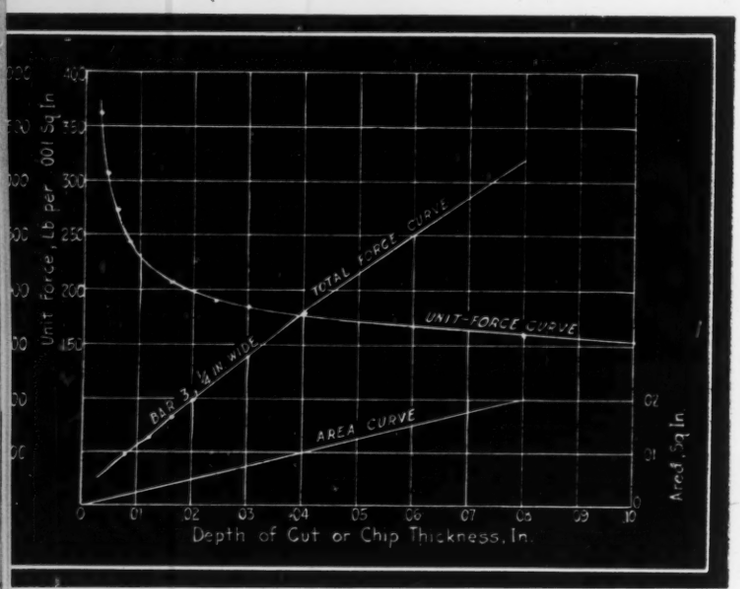

Unit Force, Lb per .001 Sq In.
TOTAL FORCE CURVE
UNIT-FORCE CURVE
BAR 3 1/2 IN. WIDE
AREA CURVE
Area, Sq In.
Depth of Cut or Chip Thickness, In.

Fig. 2—Force to remove chip one-quarter inch wide, turning .15 per cent carbon steel at twenty feet per minute cutting speed

higher than those for planing, as might be expected.

If the rake of the tool or the size of cut were changed, the above values would be altered. They would be reduced in almost direct proportion to an increase in rake angle. They would be increased if the feed or thickness of chip were reduced. The influence of the thickness of chip as represented by the depth of cut when planing the top of a land of uniform width is shown in *Fig.* 2. The area-of-cut curve is a straight line varying directly as the depth of cut. The total-force values at the tool point, as obtained with a dynamometer, form a curve nearly straight, but concave downward at the lower left. The total force divided by the area of the cut producing that force gives the unit force, the values of which are shown plotted as a curve having the greatest value for the thinnest chip. This shows that thick chips are removed more efficiently, from a force or power point of view, than thin chips. The equation for the total force curve is $F = 81{,}300\ wt^{.77}$, in which w is the width of cut and t the thickness of chip.

Wattmeter Determines Cutting Force

In nearly all types of metal cutting processes, the cutting force remains practically constant as the cutting speed is varied. This statement does not hold for speeds below 10 to 20 feet per minute.

In a series of turning tests on a lathe, the net horsepower at the tool point was obtained by subtracting the tare power in kilowatts from the gross as recorded on a wattmeter. The gross power was obtained with a lathe under full cut. The tare was obtained with the lathe operating with all gears engaged but not cutting. Representative values are shown in TABLE I.

In the first test, a tool of high-speed steel had a shape of (8,22,6,6,6,15,3/64) 8-degree back rake, 22-degree side rake, 6-degree side relief, 6-degree end relief, 6-degree end-cutting-edge angle, 15-degree side-cutting-edge angle and 3/64-inch nose radius. The feed f was .01-inch per revolution, depth of cut d was .05-inch, and cutting speed V was 150 feet per minute. The tool life T was 18.02 minutes. The cubic inches of metal cut per minute was .9 and equals $f \times d \times 12V$. The gross power was 1.7 kilowatt, the tare was 1.1 kilowatt, giving a net power at the tool point of .6 kilowatt. The .6 kilowatt divided by .746 gives .81 net horsepower at the tool point. This divided by the cubic inches of metal removed per minute gives the net horsepower per cubic inch per minute of .9 which agrees fairly well with the values for the similar steels SAE 2320 and SAE 2345 in *Fig.* 1. The net horsepower is equal to the tangential cutting force F

times the cutting speed V divided by 33,000. From this, F is found to be 179 pounds.

In the second cut where a side rake angle of 14 degrees was used instead of 22 in the first cut, and a cutting speed of 55 instead of 150 feet per minute, the net horsepower is found to be .4. Additional tests were run with Carboloy tools, ground to a characteristic shape of 0-degree back rake and 8-degree side rake, operating with various values of feed and depth of cut. The net horsepower per cubic inch of metal cut per minute is shown to be 1.04 for the feed of .01-inch. It is .87 horsepower per cubic inch for a feed of .03-inch. In general, it is seen that values are high for light feeds, and low for heavy feeds or for large depths.

Lathe Efficiency Is Found

The relationship between output and input power may represent the efficiency of the machine tool. This total overall efficiency is a function both of the motor and of the mechanical efficiency of the machine. In Test 1, TABLE I, it is .81/2.28 or 35.5 per cent.

Efficiency of this 16-speed geared-head lathe when developing two horsepower at the spindle was found to range from 45 per cent for the lowest speed of 18 revolutions per minute down to 37 per cent for a speed of 105 revolutions per minute, and only 26 per cent for the highest speed of 750 revolutions per minute. This would indicate that only about one-third of the power developed by the motor is delivered at the spindle. When one horsepower was developed at the spindle, the average efficiency of the lathe was 25 per cent; for three horsepower it was 50 per cent.

A dynamometer may be used on a lathe or planer to determine the tangential cutting force alone or the three components (tangential, longitudinal, and radial) of the cutting force. The usual test procedure is to have the material being machined and the tool shape constant. For one feed, values of force are determined for each of several depths of cut as shown on the left in *Fig.* 3. Again the depth may be kept constant and the forces for each of several feeds may be determined as shown on the right in *Fig.* 3. Usually, the force line, as shown on log-log paper in *Fig.* 3 for one constant feed, is parallel to all other lines in which the feed is constant. Therefore, in determining such force relationships, it is necessary to use only one constant feed and vary the depth to get one line on log-log paper.

A second line is obtained for a constant depth and variable feed as shown on the right in *Fig.* 3. The slope of these lines represents the exponent of the variable so that for the tangential component of the force F_T, as shown in the upper part of *Fig.* 3, the exponent of d is 1. The exponent of f is .83. The equation for F_T as a function of f and d is then $F_T = Cf^{.83}d$. By substituting the force for any given feed and depth in the formula, the value of the constant is obtained. For the conditions outlined in *Fig.* 3, the equations are: Tangential force $= 133{,}000\ f^{.83}\ d$; the longitudinal force $= 33{,}700\ f^{.48}\ d^{1.45}$; and radial force $= 923\ f^{.56}$.

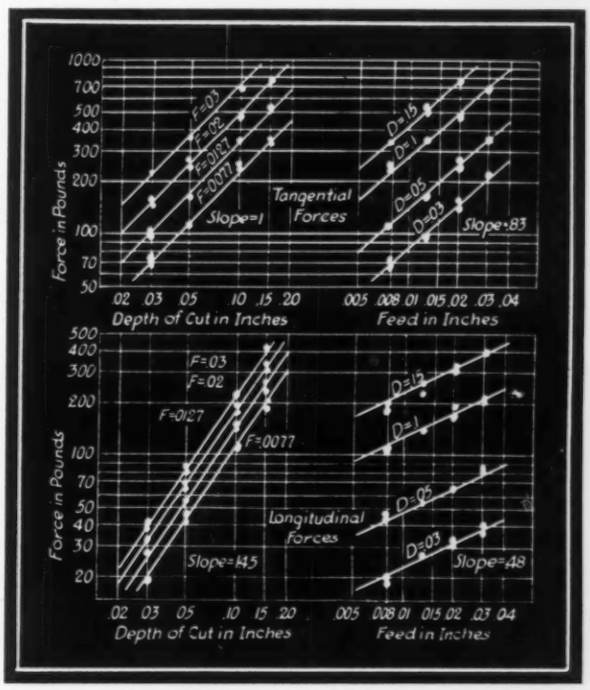


Fig. 3—Test data plotted to determine exponents in the tangential and longitudinal cutting-force equations

From these equations, values of forces can be computed for any combination of depth and feed. Cutting force equations and values of the force for a given cut in SAE 3135 steel are shown in TABLE II. To obtain the power developed by the motor, the net power as determined from these forces must be divided by the efficiency of the machine and motor. The net power developed by the radial component of the cutting force is zero inasmuch as no speed is involved. Net power developed by the longitudinal force amounts to 5 per cent or less of the total power and is determined by multiplying the longitudinal force by the feed in feet per revolution, times the revolutions of the work per minute, divided by 33,000 or $F_L fN/(12 \times 33{,}000)$. The net power developed by the tangential force component is $F_T V/33{,}000$.

Example: It is required to determine the power

TABLE II

Cutting Force and Force Equations*

	Tool No. 1	Tool No. 2
Tool signature.....	8-14-6-6-6-15-3/64	8-22-6-6-6-15-3/64
Tangential force.....	$259{,}000\ f^{.98}\ d$ 1,250 lb.	$174{,}000\ f^{.90}\ d$ 1,110 lb.
Longitudinal force...	$35{,}700\ f^{.39}\ d^{1.55}$ 480 lb.	$950\ d^{1.08}$ 123 lb.
Radial force.....	$7{,}300\ f^{.74}\ d^{.28}$ 320 lb.	$25{,}700\ f^{.84}\ d^{.58}$ 450 lb.

*When turning an annealed SAE 3135 steel dry at 50 fpm with ¾-inch square high-speed steel tool bits. Force values listed are for a depth of cut of .15-inch and a feed of .03-inch.

of a motor to take a cut of ⅞-inch feed by 1/16-inch depth at 30 feet per minute when planing heat-treated die steel, SAE 4350, having a Brinell hardness of 363. The force formula for these conditions is $F_T = 48{,}800\, f^{1.01}\, d^{1.02}$ from which F_T is found to be 25,200 lb. Net horsepower at 30 feet per minute cutting speed is 25,200 times 30 divided by 33,000 equals 23. The efficiency of the planer may be assumed to be 50 per cent which would give 46 horsepower to be developed by the driving motor.

Similar cutting force data have been obtained in the process of milling. Again the overall efficiency of the average milling machine is low, ranging from 20 to 50 per cent. *Fig.* 4 shows the net horsepower per cubic inch of metal cut per minute plotted over the feed and depth for a 3-inch diameter milling cutter having 12 teeth, a 15-degree rake angle, 25-degree left-hand helix, operating at 17 revolutions per minute when milling an annealed SAE 3150 steel with a sulphurized mineral-lard oil as a cutting fluid. These curves, straight lines on log-log paper, again show that the lowest value of horsepower per cubic inch of metal cut per minute is obtained for the largest value of feed and the largest value of depth of cut. By multiplying the values as found from these curves, or as computed from the equation shown, by the cubic inches of metal cut per minute, the total net horsepower developed at the spindle is obtained. This value should be divided by the efficiency of the machine to obtain the horsepower of the motor.

Drilling Torque Determined

The torque, thrust, gross and net power input when drilling an annealed chrome-vanadium steel, SAE 6150, Brinell 187, and a soft cast iron, Brinell 163, are shown in TABLE III.

To make it possible to determine the torque T, thrust B, or power for any other combination of diameter and feed, the following equations were determined from experiments in which the drill diameter d and feed f were varied separately: For SAE 6150 steel, $T = 1840\, f^{.78}\, d^{1.8}$, $B = 53{,}400\, f^{.78}\, d$, and for cast iron, $T = 380\, f^{.6}\, d^2$, $B = 14{,}720\, f^{.6}\, d$.

Values of torque for any drill diameter and feed, for SAE 1020, may be obtained from the log-log graph, *Fig.* 5. For other steels, torque may be obtained by multiplying the value from *Fig.* 5 by the following factors: .9 for SAE 1035, 1.06 for annealed tool steel, 1.15 for annealed SAE 3150, and .69 for SAE 1112 steel.

The total net horsepower developed at the drill point equals the horsepower due to the torque plus the horsepower due to the thrust, or total horsepower $= 2\pi Tn/33{,}000 + Bfn/(12 \times 33{,}000)$.

To illustrate, the 1¼-inch diameter drill with a feed of .015 inch, rotating at 175.1 revolutions per minute (60 feet per minute) when cutting SAE 6150 steel, TABLE III, has a torque of 110.8 pounds-feet and thrust of 2,430 pounds. Substituting these values in the above equation, the horsepower due to torque is 3.694 and the horsepower due to thrust is .016, a total of 3.71 horsepower.

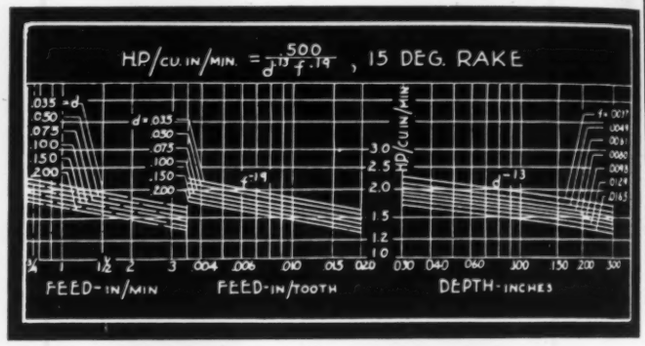


Fig. 4—Net horsepower per cubic inch per minute plotted over feed and depth of cut in turning

It can be seen that the horsepower due to the thrust is only .43 per cent of the total power developed, so for power purposes the horsepower output due to the thrust may be neglected. It is of importance in design, however. TABLE III shows that

TABLE III

Torque, Thrust and Power in Drilling

Material	Drill Dia. (in.)	Speed rpm	Feed (in./rev)	Torque (lb-ft)	Torque Horse-power (hp)	Thrust (lb)	Thrust Horse-power (hp)	Total Output (hp)	Input Power Gross (kw)	Input Power Tare (kw)	Input Power Net (kw)	Net Input (hp)	Efficiency (%)
SAE 6150 Steel....	½	444.5	.009	14.0	1.185	725	.00732	1.193	1.6	.67	0.93	1.24	96
	⅝	368.0	.011	22.3	1.562	838	.00856	1.571	2.025	.67	1.355	1.81	87
	¾	299.7	.012	34.3	1.957	1269	.01153	1.975	2.42	.67	1.75	2.34	84
	1	228.1	.013	62.4	2.71	1862	.01394	2.724	3.176	.57	2.606	3.49	78
	1¼	175.1	.015	110.8	3.694	2430	.01611	3.710	3.87	.57	3.3	4.42	84
	1½	149.0	.015	143.3	4.07	3000	.01693	4.087	4.507	.507	4.0	5.35	76
Cast Iron	½	446.0	.009	6.3	0.535	530	.00614	0.541	1.12	.67	0.45	0.602	90
	⅝	364.4	.011	10.2	0.708	645	.00652	0.715	1.32	.67	0.65	0.870	82
	¾	299.7	.012	15.7	0.896	803	.00728	0.903	1.48	.67	0.81	1.084	83
	1	229.8	.013	27.9	1.221	1088	.00822	1.23	1.72	.50	1.22	1.635	75
	1¼	179.4	.015	46.4	1.585	1403	.00954	1.60	2.025	.45	1.575	2.110	76
	1½	153.4	.015	65.9	1.925	1700	.00988	1.94	2.27	.37	1.90	2.550	76

*Standard twist drills were used with 31-degree helix angle, 121-degree point angle, 136-degree chisel-edge angle and 5-degree relief angle. The ratio of web thickness to diameter was .14 for the ¾-inch and larger drills, .162 for the ½-inch diameter drills, and .185 for drills up to ⅜-inch diameter. Speed 60 feet per minute. Cutting fluid emulsion 1 part soluble oil to 16 parts water.

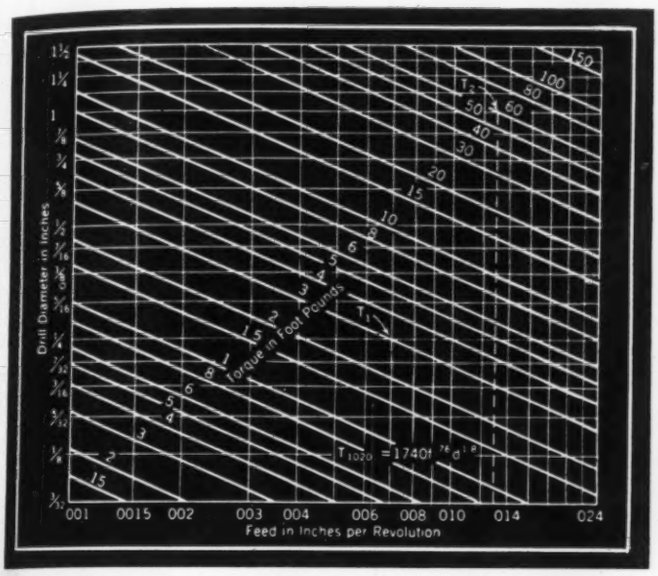


Fig. 5—Torque when drilling annealed SAE 1020 steel, plotted as a function of drill diameter and feed

the efficiency of the machine as determined by dividing the input by the output is highest when using small drills operating at high speed with resulting low values of torque and thrust. Similarly, the efficiency is lowest when the torque and thrust are high, even though the speed of the machine is less. It has been found that torque and thrust are affected but little by a change in cutting speed. Power, however, is a direct function of speed, as illustrated above.

The horsepower per cubic inch of metal cut per minute is obtained by dividing the total power by the cubic inches of metal cut per minute, v. These formulas are, for the SAE 6150 steel, $Hp/v = .466/(d^{.2} f^{.22})$ and for the cast iron, $Hp/v = .092/f^{.4}$. Net horsepower per cubic inch of metal cut per minute is lower for larger values of feed and drill diameter.

Silver Finds New Uses

REPLACEMENT of metals that have become scarce due to the war has spurred the use of silver as an engineering material. Sufficient silver is available in the world markets and its cost is actually lower than several other metals, such as tungsten, molybdenum and beryllium, now being used in large quantities. With a high reclaiming value, silver increases the intrinsic value of parts in which it is used. Apart from its value as a substitute material, it has properties which entitle it to a high place on the list of engineering metals in direct competition with other materials.

Soft solders containing no tin are finding increasing use. Such silver-lead solders are actually cheaper than comparable tin solders because of the fact that only 2.5 per cent of silver is used compared with nearly 50 per cent of tin. Melting of this lead-silver solder starts at 580 degrees Fahr. and the flow point is approximately 661 degrees Fahr., which makes it suitable for joining dissimilar metals at relatively low temperatures.

Brazing alloys or hard solders made with silver have extreme fluidity and easily penetrate narrow openings, resulting in a strong joint with a minimum amount of brazing material.

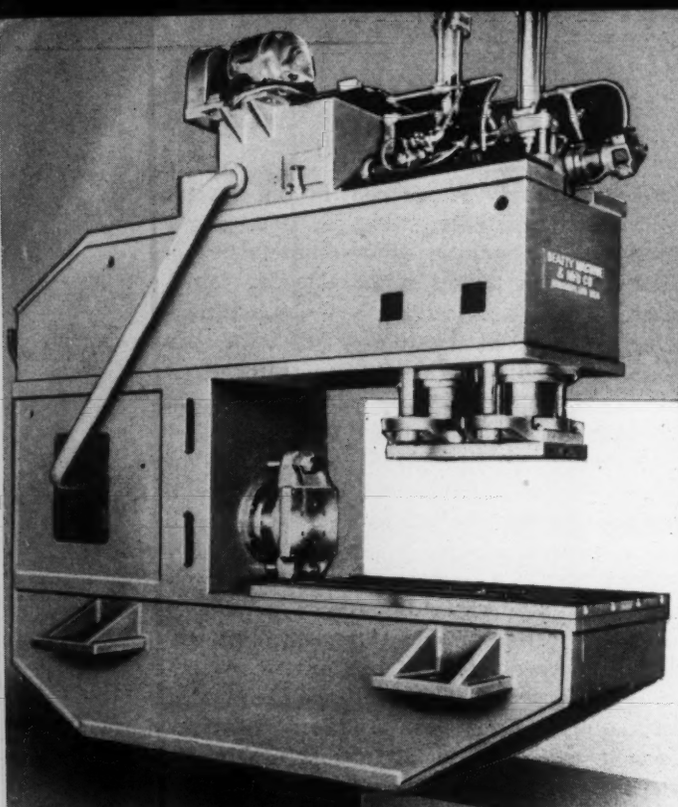
Babbitt metal is being replaced with silver alloys in airplane engine bearings not only to save tin but also to increase the strength of the bearing at high temperatures.

Promising results have been reported from lightweight silver-rich magnesium alloys suitable for aircraft structural purposes. One such alloy, containing 2.6 per cent each of aluminum and zinc, 5.5 per cent of silver, .2 per cent manganese and the rest magnesium, has been produced in extruded bars, rolled sections and large forgings, and is reported to have a yield strength of 32,000 to 50,000 pounds per square inch, depending on the heat treatment. Corrosion resistance is comparable to commercial magnesium alloys and the specific gravity is only 1.89.

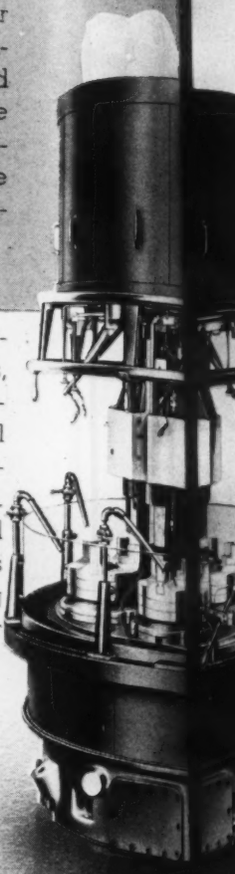
Electrical conductivity of silver is the highest of any metal, and a novel method of storing the Treasury's hoard is in bus bars instead of copper. When the copper shortage is at an end, the silver in the bus bar will be returned to the Treasury.

High resistance to corrosion and to the attack of many chemicals makes silver valuable as a lining in the chemical industries in place of nickel plate, copper or stainless steel. In this application the silver is rolled on to steel rather than electroplated.

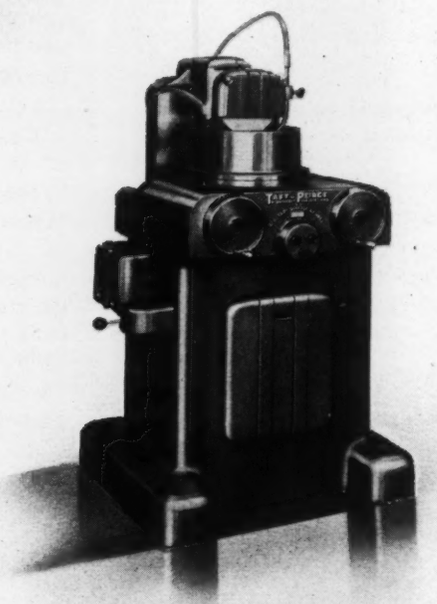
CORRECTION: The shell welding machine illustrated on last month's cover and reproduced above was titled erroneously on the contents page of that issue. Actually, the manufacturer of the machine is the Thomson-Gibb Electric Welding Co. of Lynn, Mass., and the title for the cover should have read "Thomson-Gibb Shell Welder".



Left—Production in the shipbuilding and other vital war industries is accelerated by the manually controlled Beatty hydraulic forming and flanging press. The vertical cylinders can be operated independently when flanging, or together as a single 400-ton press. A feature is the self-cooling hydraulic oil system, eliminating need for cooling coils

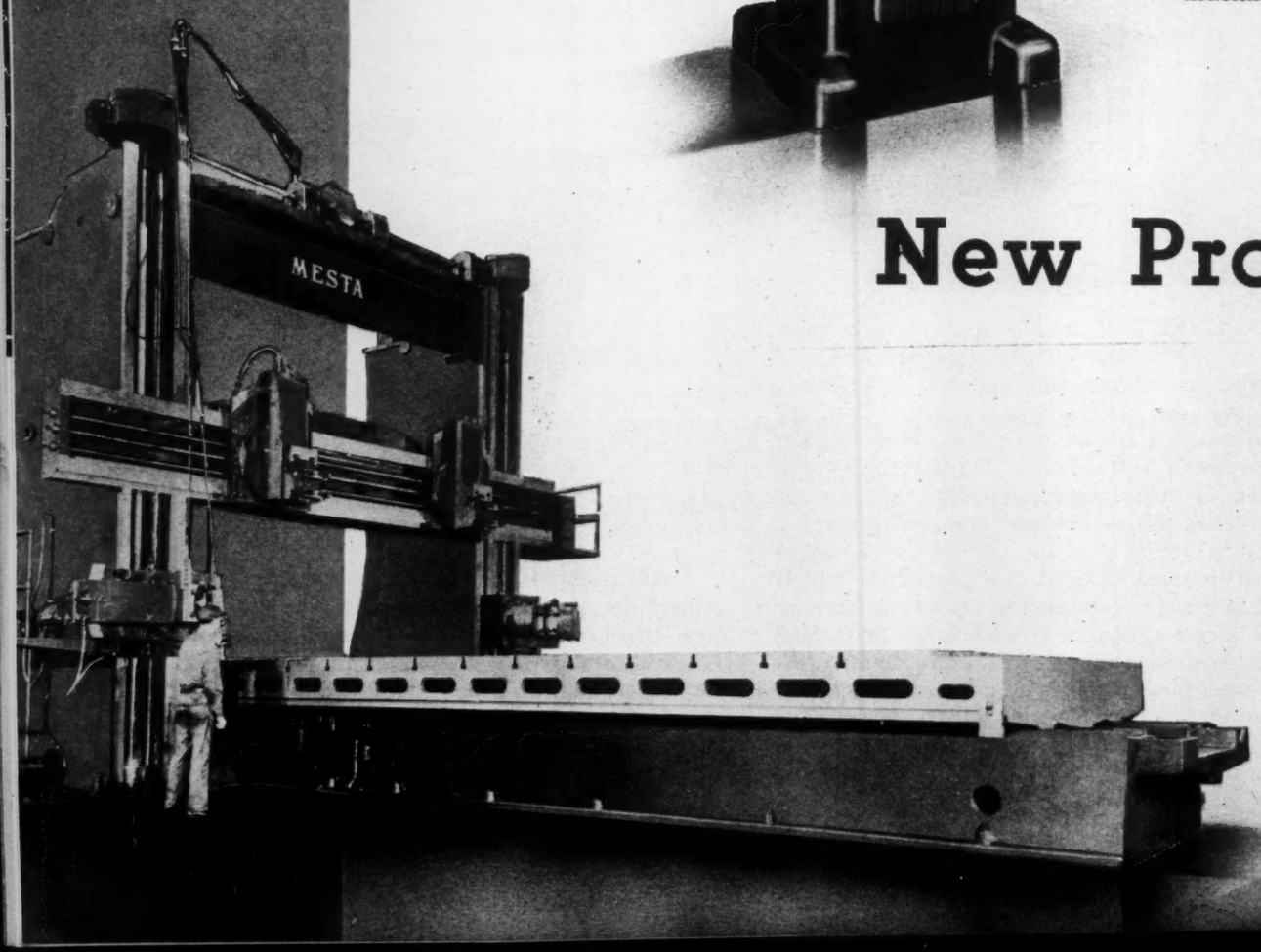


Below—Designed for the production of surfaces with exceptional accuracy of flatness, the new Taft-Peirce surface grinder incorporates hardened and ground ways and ball bearing travel of saddle and column to eliminate difficulties due to variation of oil film. The spindle is carried in an accurately bored cast iron block mounted between two pairs of circular dovetail slides, permitting swiveling of the entire spindle about the wheel center



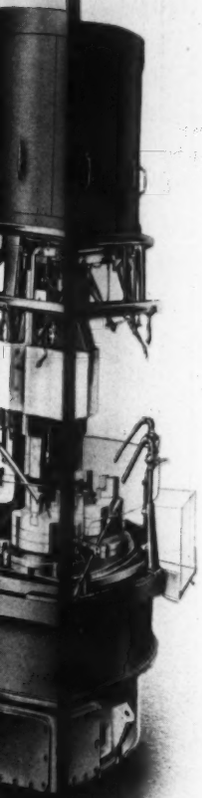
Above—Higher speeds ... tougher work materials ... in c... duction for victory impose... loadi... the Bullard Mult-Au-Mat... signe... stand. Tool heads ope... n h... ways meet the demands ... ern t... machining operations. ... ete ... lubrication elimina... ue w...

Below—Tool heads with automatic tool lifters and electric feed are features of the Mesta double-housing planer. The table is arranged for variable voltage control and has a thirty-to-one speed range



New Product...

(For new machin... see P...



speeds ... feeds and
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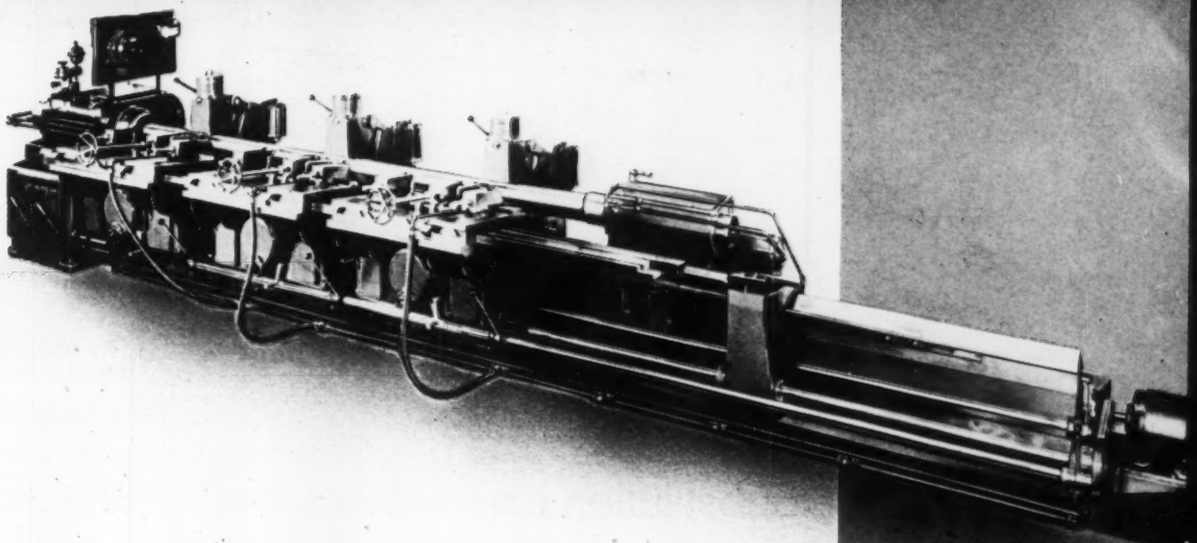
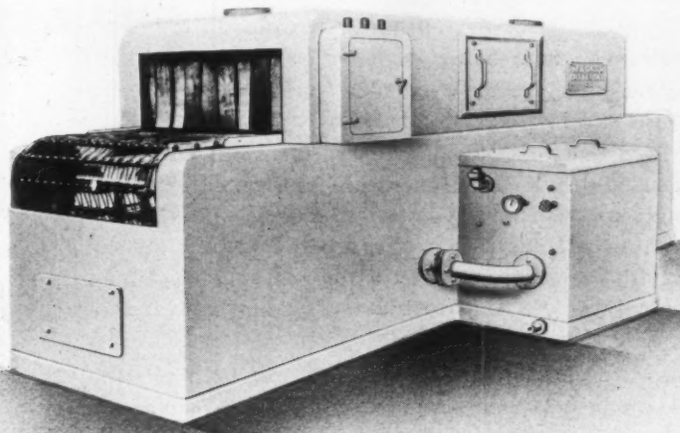


Above—Multiple tooling increases production of large gun barrels on the Lo-swing lathe. The three carriages each hold three tools and can be rapid-traversed in either direction independently or together for quick set-up. Roller-type steady rests rigidly support the work while being cut, and chip disposal is facilitated by sloping the rear bed down at a 20-degree angle

Below—Metal washing is effectively accomplished in the compact Magnus Emulso-Spray machine. An endless conveyor carries the parts through a petroleum solvent wash at room temperature, a water rinse and a hot air drying section. The rapid cleaning action of the process simplifies design by making possible a short unit for normal conveyor speeds without having to use hot solvents

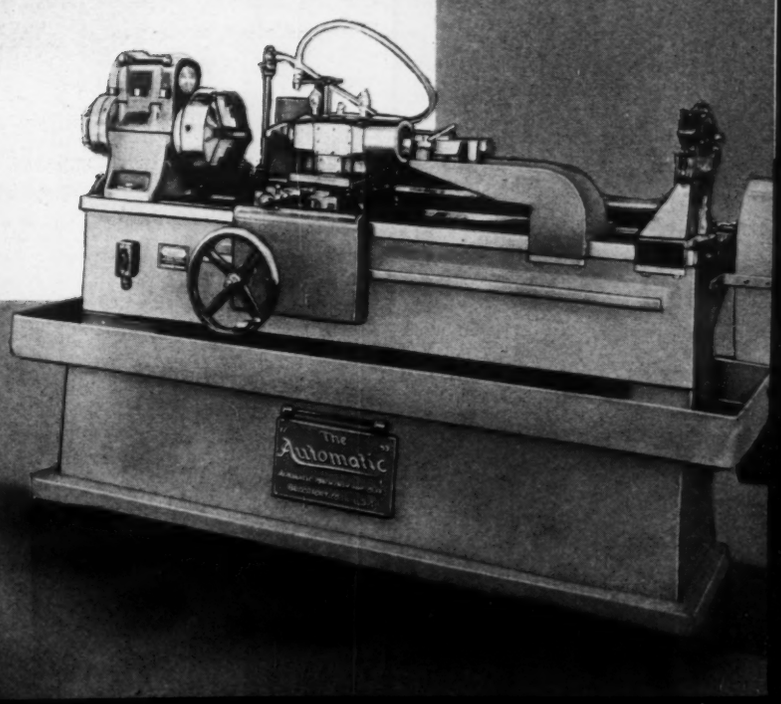


Below—Designed for accurate thread production, the Automatic universal hob thread milling machine features a work spindle which swivels on the bed so that straight or taper, internal or external threads may be milled, using standard hobs without special taper attachments. Hob spindle and work spindle are driven by worm gears from the same driveshaft, and the entire mechanism is mounted on a welded base

ct n Machines

machin ... ee Page 166)

Left—Fuse bodies or other parts with conical or straight-sided surfaces can be marked at the rate of two per second in the Matthews fuse-marking machine. A cast base supports the motor-driven rotating pressure dial, which conforms to the contour of the piece to be marked. The fuse bodies are rolled between the pressure dial and the type holders



MACHINE DESIGN *Editorial*

Substitutions and Alternatives Will Keep Production Rolling

RECENT remarks of leaders in the governments and industries of the United Nations display definite feelings of optimism as to the length and outcome of the war. One of the most significant utterances in this respect is that of Winston Churchill to the effect that "the ridge, though not surmounted, is now in sight".

Caution is evident in most of these comments. It is clear that the speakers, though wishing to raise the spirit and morale of their audiences, are anxious not to create too great a feeling of security with a resulting let-down in the all-out war effort.

Designers of machinery, in particular, cannot yet afford to "rest on their oars". Since all machines now being designed are war machines—either direct or indirect—development of new machines and redesign of earlier models constitutes one of the most essential factors in the march to victory.

Development of improved machines from an operating standpoint is not now, however, the only task with which designers are confronted. They may rightly be expected as engineers to apply their knowledge of manufacturing processes to the achievement of still higher rates of production. At the same time they will be credited with the responsibility for the continuance of manufacture on a vast scale through the use of substitute materials wherever shortages exist or are in sight.

Elsewhere in this issue are given examples of the use of both substitute materials and alternative methods of manufacture. It is impossible under wartime conditions to give detailed information on instances of similar nature related to direct armament equipment. One of the primary aims of MACHINE DESIGN'S editors, therefore, is to present such information as rightly can now be published, to aid designers of both direct and indirect war machinery in the application of similar substitutions and alternatives in their design work.

It is conceivable that a point might soon be reached at which the unavailability of raw materials, especially those of strategic or critical nature, would limit the production of war equipment. What better service could the designer perform than to foresee such potential shortages in the materials of his selection—and to forestall any let-up in speed of production by the development of alternative designs?

L. E. Jerry

Designing Accelerated-Motion Cylindrical Cams

Part I

By Nelson K. Bennett Sr.

CALCULATIONS for accelerated-motion cylindrical cams can be made in five steps, consisting of five sets of formulas presented in data sheet form in two parts, in this and the July issue. Starting with the basic data, the general procedure is first to determine the helix angle for a uniform motion cam having the same diameter, throw and radius as the desired accelerated cam. After this has been done by means of the formulas associated with *Fig.* 1, the four subsequent sets of fomulas carry the calculation of the cam groove to completion.

Basic Data

C = Circumference of cam (on O.D.)
T = Throw of cam
W = Width of cam groove
r = Radius of inside corner of cam groove
R = Radius at center line of cam groove
U = Per cent acceleration (in last division)
n = Number of divisions (to be selected)

$$A = \frac{T}{2} - R \qquad D = \frac{A}{\sin B}$$

$$B = \tan^{-1}\frac{4A}{C} \qquad E = \sin^{-1}\frac{R}{D}$$

$$F = B + E = \text{helix angle}$$

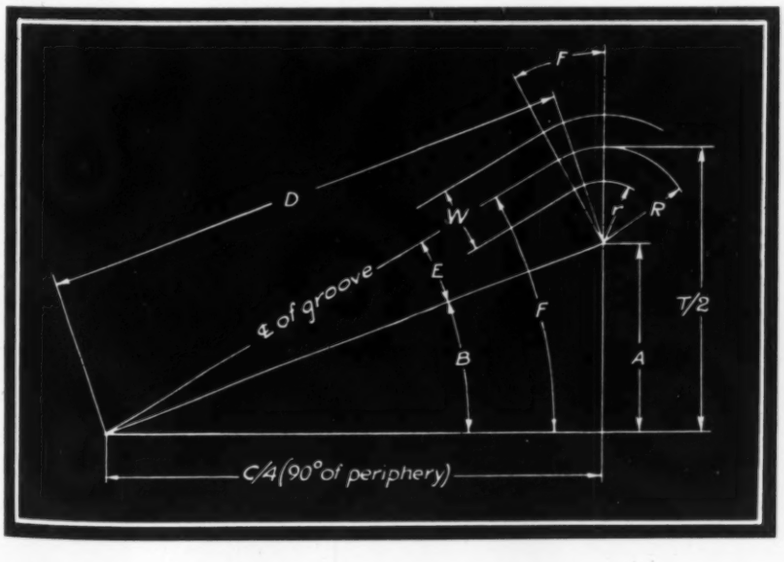


Fig. 1—Solution of helix angle for a uniform-motion cam is first step in calculating accelerated-motion cam with the same diameter, throw and radii

Known values:
F = Helix angle (as found in Section 1)
U = Per cent of acceleration (in last division)
n = Number of divisions (to be selected)

$A\&B$ (alike for uniform motion cam) $= R \sin F$

$M\&N$ (alike for uniform motion cam) $= R \cos F$

$X\&Y$ (alike for uniform motion cam) $= R-M,\ R-N$

$$D=\frac{C}{2}-(A+B) \qquad a=S/w=\text{traverse in first division}$$

$$S=T-(X+Y) \qquad b=a(U+1)=\text{traverse in last division}$$

$$w=\frac{n}{2}U+n \qquad d=\frac{b-a}{n-1}=\text{common traverse in consecutive divisions}$$

$(a+d)$, $(a+2d)$ *etc.* = traverse in 2nd, 3rd, etc., divisions

S = sum of traverses of all divisions

Note: Due to the necessity of relocating the tangent points at each end of the accelerated period, as will be found in connection with *Figs.* 3 and 4, the above values may change in revised final calculations under *Fig.* 5.

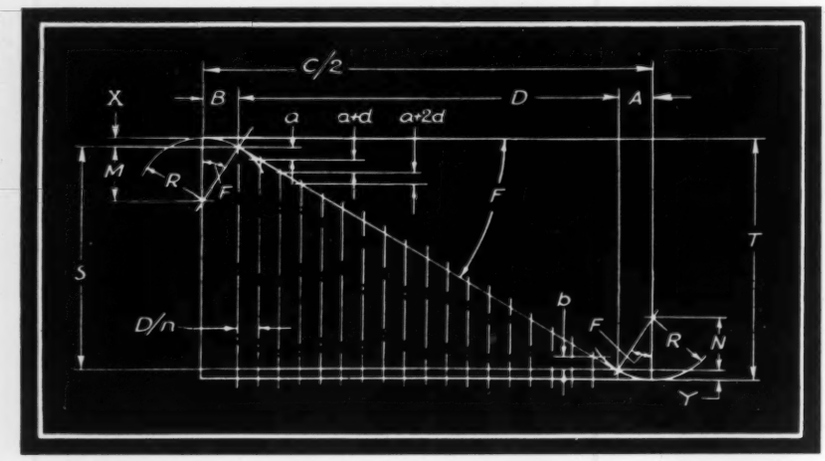


Fig. 2—Based upon the uniform-motion cam, the second step yields a first approximation of the increments for path of cam groove

Known values:
a = Traverse in first division (Section 2)
D/n = Spacing of divisions

$$B=\tan^{-1}\frac{an}{D} \qquad P=R\cos B$$

$$M_1=R\sin B \qquad Q_1=R-P$$

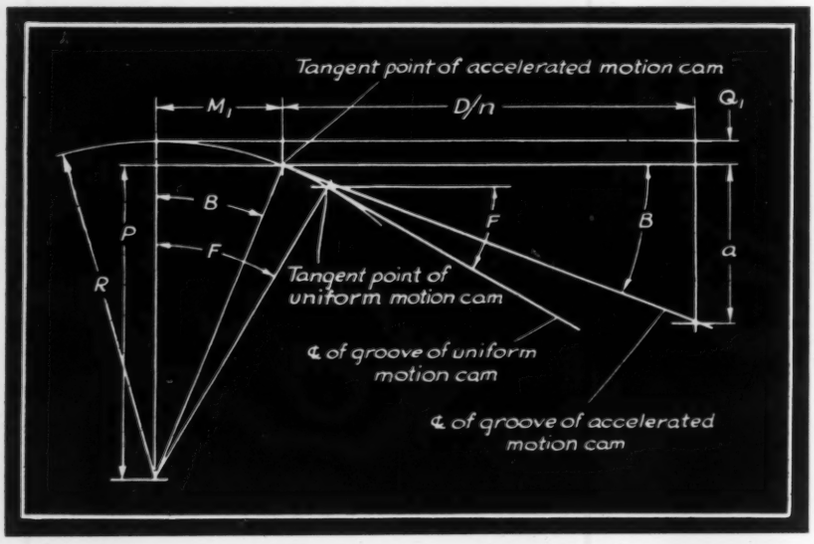


Fig. 3—Due to the desired accelerated motion, a relocation of the tangent point of the groove with the first division end arc is necessary

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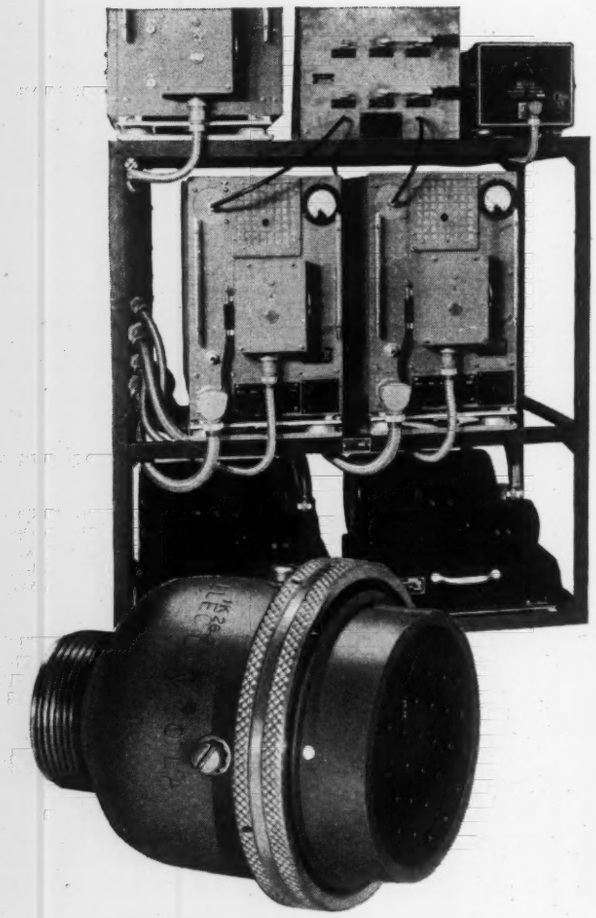

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Professional Viewpoints

"... demands for better machines"

To the Editor:

Congratulations on the editorial in the April issue of MACHINE DESIGN. "Production now" is what the nation must have and what we on the design end of the line must give and give to the fullest extent of our ability. And yet we must not blind ourselves to the needs of the immediate future nor to its demands for better machines that do better work with better economy; we must not be deaf to the reports that come from those that operate our machines, whether they be on the fields of battle or on the home front.

In my own somewhat specialized work several lines of machines are shipped out as fast as the shops can assemble them and the testing floor can "okay" them; we have made changes only where the shortage of certain materials has made that the better patriotism. Meanwhile we are, insofar as time permits, busy with new and improved designs which will be released to the shops when that can be done without flattening the upward gradient of our shipment curve. This means, as you say, "Stabilization—Not Stagnation"!

—CLYDE HEARN
Jersey City, N. J.

"... timely attention to design"

To the Editor:

In "Playing Hob with Involute Gears" in your April issue, John D. Howell has drawn timely attention to a neglected aspect of gear design. Too many engineers think only of completely interchangeable gear tooth systems, and specify gear-cutting details in these terms. Except where the gears must be cut in a jobbing shop and only a standard milling machine with form cutters is available, or where change-gears are needed, rigid adherence to standard proportions is unnecessary. For bevel gears, modified tooth proportions have for some time been standard practice, and there is no reason why spur gears cannot also be individually designed. The increased center distance method of correction described in the article is the most universally applicable, and yet is perhaps the least known.

Finer points of gear design technique are not as widely understood as they should be by engineers who are not gear specialists. Gear design

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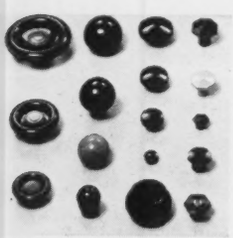

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information in a specific, clearly understood form is badly needed, and by publishing Mr. Howell's contribution MACHINE DESIGN has taken a step in the right direction.

—WILLIAM STEWART
New York

" . . . no limitation to gear design"

To the Editor:

Referring to Mr. Howell's article "Playing Hob with Involute Gears" in your April issue, it is sound and the crossed belt analogy is good—I have often used it myself. I am very much in favor of hammering home the fact that with the involute form, and with a standard generating tool such as a hob, there is no limitation to the form or design of the involute gears, either spur or helical. Special and standard conditions can generally be met, and met adequately, provided the designer or engineer will use a little "gray matter" and relax awhile as he grinds the crank of a calculating machine.

—*Earle Buckingham*
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

" . . . method of attack is new"

To the Editor:

I wish to express my appreciation of the articles "Applying Mobility Method to Vibration," by Professor Binder, appearing in February and March MACHINE DESIGN. The method of attack is so new, and these vibration problems of such importance, that a real demand should exist for a reprint, or even better, for a booklet giving even more detailed explanations and several more specific numerical examples. This mobility concept appears especially valuable in handling the geared drives, which cause much trouble by former methods.

For the possible assistance of other readers in applying Professor Binder's articles may I offer the following practical comments, referring primarily to the article on linear vibrations on Pages 57 to 60 of the March issue:

The introduction could well include the basic equation $v=FZ$ and mention that the nomenclature is given at the end of the article. This nomenclature should include ϵ and C, the resistance constant.

In both articles the author states "the angle of this complex number is the angle by which the velocity leads the force," and also gives in TABLE I a list of instantaneous values involving complex number exponentials. The average engineer is even more rusty on this phase of mathematics than on differential equations, and is apt to be scared away from the whole method.

Since neither the angle of the complex number, nor the exponentials appear again in either the linear or the torsional vibration studies, they could perhaps be omitted. At least it should be pointed out that the engineer can use the mobility method in solving complex actual cases, knowing only that

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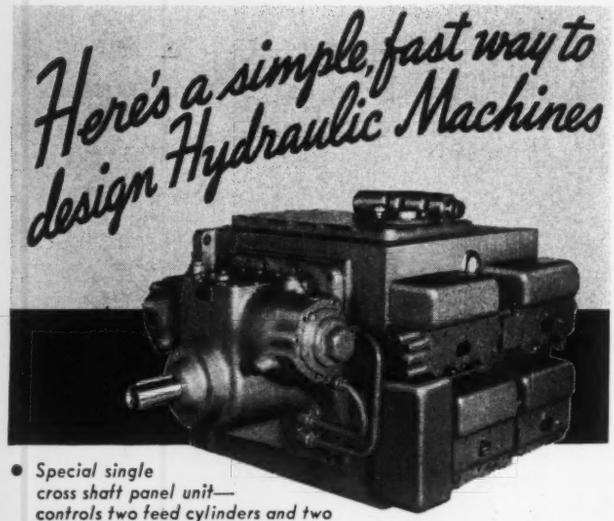

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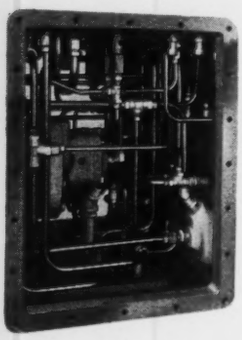

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These standard hydraulic units are in use in mass production machine tools in all of our prominent automotive plants . . . in simple and complicated machining cycles. For additional data write for the booklet offered below.

FREE New Data: Included in this 40 page book are typical installation circuits, complete data covering piston and gear pumps and complete information covering basic elements of construction and installation of standard units used in these highly successful hydraulic circuits. Write for your copy today. Ask for Bulletin MD 642.

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ROCKFORD, ILL.

j or $(-1)^{\frac{1}{2}}$ is imaginary, but j^2 is -1, a real number usable in calculating actual values. Sometimes also, the imaginary j cancels out, as in Equation 2 on Page 58.

The author comments on Equation 4, Page 59: "Since the denominator in Equation 4 will never be zero. . ." This is because a complex number $1/j\omega l$ can never be equal to a real number, or to a complex number plus a real number, such as $1/r$.

As the author himself points out, the continued fractions involved in the mobility method, if carried beyond 3 or 4 variables, get cumbersome to handle algebraically. As an example see Equation 6, involving only five variables, namely the two masses, and the three springs. However, these continued fractions become simple if the actual numerical values of a given problem are substituted for the algebraic symbols.

The general case of Equation 6 is of such importance as to merit comment. The complex algebraic expression in this equation is derived by converting the basic continued-fraction equation

$$c=\cfrac{1}{\cfrac{1}{i\omega l_3+\cfrac{1}{\cfrac{1}{i\omega l_2}-\cfrac{\omega m_1}{j}}}-\omega m_2+\cfrac{1}{i\omega l_2}}$$

into the simple fraction of Equation 6 having only a single numerator and a single denominator.

This general case has three natural frequencies, since there are three values of ω which will reduce the denominator to zero, giving infinite mobility. Studying this denominator of Equation 6, it reduces to zero for a value of ω such that the last two terms, $l_2-\omega^2 l_1 l_2 m_1$ become zero and also either one of the terms in parenthesis. This is the case when $\omega^2=1/m_1 l_1$ and is also equal to $1/m_2 l_2$. Hence this natural frequency is $\frac{1}{2}\pi(m_1 l_1)^{-\frac{1}{2}}$ and $m_1 l_1$ must equal $m_2 l_2$. Thus, if mass m_2 is large, its spring l_2 must be stiff (small compliance), and similarly for m_1 and l_1.

Also, the denominator in Equation 6 is equivalent to a second degree equation in x where $x=\omega^2$, having two real roots, hence ω has two real values. This second degree equation appears cumbersome but is readily solved for an actual case in which real numbers are substituted for the algebraic masses and compliance of Equation 6, before solving.

Hence in the general case of Equation 6 there are *three* natural frequencies.

The writer has solved the equation represented by the denominator in Equation 6, set equal to zero, for the author's special case of Equations 7 and 8 in which the masses and compliances are all equal. The solution gives two roots resulting in the same natural frequencies as in the author's Equation 8. One of these frequencies, namely $\frac{1}{2}\pi(lm)^{-\frac{1}{2}}$ duplicates the natural frequency found by reducing the denominator of Equation 6 to zero.

Thus the general system of *Fig.* 4 has three frequencies, two of which become identical for the

PROMPT DELIVERY IS ONLY ONE WARTIME FEATURE

ON TODAY'S rush production schedules, *ready availability* is an outstanding feature of the Torrington Needle Bearing. Thanks to a program of steady expansion, Needle Bearings can be delivered promptly in standard sizes and types *on all priority orders.*

But the features that first won industry-recognition for the Needle Bearing are now important wartime advantages, too. See if you don't agree that each one fills an immediate need, simplifying your product design and speeding production.

YOU SAVE TIME installing the Needle Bearing. It is built as a single compact unit. One quick operation presses it into place in the housing. Here is modern design for today's high speed production line methods.

YOU CONSERVE VITAL MATERIALS. The Needle Bearing's small outside diameter represents a material saving in itself. And this in turn enables you to reduce the size of surrounding members, conserving still more materials for needed use elsewhere.

YOU ELIMINATE EXTRA PARTS and assembly steps. The Needle Bearing stays in place without the aid of retaining rings, washers or end plates. And efficient lubrication eliminates the need for all but occasional renewal of lubricant. Both of which again save vital materials.

YOU IMPROVE PRODUCT PERFORMANCE. The Needle Bearing's high load capacity, low power consumption and long life make improvements possible in your product design and operation, reducing manufacturing costs.

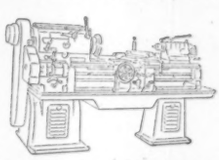
These advantages of the Needle Bearing—proven conclusively in thousands of applications—can help you guard against production delays that are more costly now than ever. Find out from a Torrington engineer how easily this unique bearing, available for prompt shipment on priority orders, can be adapted to your wartime designs. Complete details are available in Catalog No. 109. Write, wire or phone for your copy today.

THE TORRINGTON COMPANY
TORRINGTON, CONN., U. S. A. • *Est. 1866*
Makers of Needle and Ball Bearings
New York Boston Philadelphia Detroit
Cleveland Seattle Chicago Los Angeles
San Francisco Toronto London, England

LET'S GO! U.S.A. KEEP 'EM FLYING!

TORRINGTON NEEDLE BEARING

LOW MAINTENANCE COST



Used in the feed boxes of 12-inch to 18-inch heavy-duty and 17-inch to 24-inch Regal lathes manufactured by The R. K. LeBlond Machine Tool Co., Needle Bearings reduce the need for maintenance attention, because of their simple, effective system of lubrication and their long life.

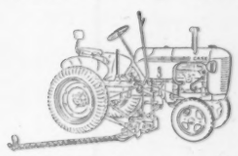
R. K. LEBLOND

HIGH-SPEED OPERATION

35 Torrington Needle Bearings are used in construction of 600 ampere, 1,500,000 Kva outdoor type oil circuit breakers built by Allis-Chalmers Manufacturing Company. Located at key points in mechanism, the Needle Bearings aid in maintaining high-speed operation.

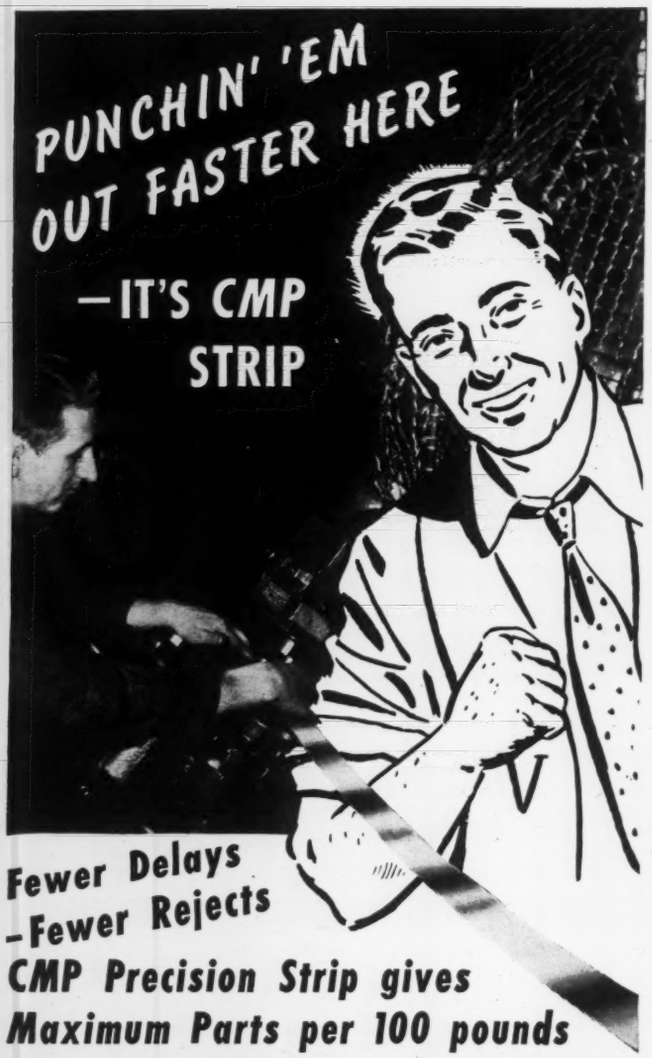
ALLIS-CHALMERS

INCREASED EFFICIENCY



Needle Bearings on power lift shafts and in universal joints on propeller shafts increase operating efficiency and conserve power in the No. 14 Case-Detroit Highway Mower. In addition, the Needle Bearings provide high load capacity for both oscillating and rotating service.

CASE-DETROIT



Fewer Delays
-Fewer Rejects

CMP Precision Strip gives Maximum Parts per 100 pounds

In many wartime industries, where important stamping and drawing operations have been "speeded up", CMP Strip is showing its inherent "extra" advantages. It's nothing new, but superiority always exhibits itself under fire — CMP accuracy, precision and uniformity of desired physical properties in coil after coil has consistently met the most rigid specifications, improved products and generally lowered costs. It takes just this kind of steel today to get maximum uninterrupted production from each vital ton. Again in the certain peacetime tomorrows CMP Strip, as before, will be the solution to many material problems for product betterment. Why not investigate its possibilities for your war products now?

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THE COLD METAL PRODUCTS COMPANY
Subsidiary of
The Cold Metal Process Company
YOUNGSTOWN, OHIO

HOW CAN CMP HELP YOU?

A wealth of valuable information on cold rolled strip steel, its uses and fabrication, is available from the extensive experience of the CMP personnel—ask a CMP representative or write, wire or phone Youngstown 4-3184.

special case of equalized masses and compliances. Comments on the physical interpretation of this third natural frequency would be interesting.

Note that Equation 11 is true only for the simplifying assumption of equalized masses and compliances, introducing Equation 7. Also, to find the S_1/S_2 ratios, the *circular* natural frequencies $(3/lm)^{1/2}$ and $(1/lm)^{1/2}$ from Equation 8 must be inserted in Equation 11.

In developing Equation 12, to find s_2,

$$v_A = F_A Z_A = F_B Z_A = Z_C F Z_A / Z_B$$

hence $s_2 = v_A/j\omega = Z_A Z_C F / j\omega Z_B$

In the last paragraph on page 60, the author states: "m is the mass of the unbalance and d its distance from the center of the shaft." In this case, m must be the mass of the entire motor, plus the vibrated portion of the beam, and d must be the distance from the unbalance-shifted center-of-gravity of the entire rotating assembly, to the axis of rotation.

On Page 134, the derivation of Equation 14 will be more readily understood by noting that

$$s_B = F Z_B / j\omega$$

and the final equation is obtained from

$$S_B = \frac{m\omega^2 dj}{j\omega}\left(\frac{1}{\frac{1}{\omega l} - \omega m}\right)$$

by multiplying the numerator outside the bracket by ωl and dividing the denominator inside the bracket by ωl, giving Equation 14.

— ROBERT E. BRUCKNER
Vineland, N. J.

"... defining number of frequencies"

To the Editor:

Mr. Bruckner's practical suggestions are very good. Regarding his interpretation of the third natural frequency from Equation 6, comments on this point center around the question of just what is meant by "number" of natural frequencies.

Considering the case in which definite numerical values for l_1, l_2, l_3, m_1 and m_2 are inserted in the denominator of Equation 6, if this denominator is set equal to zero, two real values of ω are obtained. These two values are called the natural frequencies of the system. If another set of values are taken, two other values of ω are obtained. A total of an infinite number of natural frequencies could be obtained for a total of an infinite number of different systems. The article meant that for a definite set of values of l_1, l_2, l_3, m_1 and m_2 there are two real values of ω for which the denominator is zero.

If the particular case in which $m_2 l_2 = m_1 l_1$ is taken, then setting these values in the denominator second degree equation in x, where $x = w^2$, gives for the two real roots: $\omega_1^2 = 1/m_1 l_1$ and $\omega_2^2 = 1/m_2 l_2$.

—R. C. BINDER
Purdue University

ZINC IN WAR

PROTECTING THE MERCHANT MARINE

The United States must not only out-produce our enemies, we must see to it that this matériel reaches the far flung fighting fronts. To this end America has dedicated itself to the most gigantic ship building program in all history—and these vessels must be made as efficient as humanly possible for the courageous men who sail them.

Zinc plays an important role in protecting metal surfaces, and thus protecting men at sea. Working metal parts on ships can easily be fouled by rust. To insure efficient operation when emergencies demand quick action, such important parts as life-boat davits, shown above, are sprayed with protective zinc coatings. The corrosion-inhibiting properties of galvanized (zinc coated) iron or steel are well known —and sprayed zinc dust provides this same measure of protection for metal surfaces which do not lend themselves to galvanizing.

The photographs in the background of this advertisement show: (1)—left to right—Cast iron sheaves for life-boat davits before finishing, after grit blasting and after spraying. (2) Stacks of completely finished sheaves. (3) Grit blasting the sheaves and (4) Spraying them with zinc dust using a special gun.

Other important uses for sprayed zinc include marine floats, airplane pontoons and canal gates. The needs of the Navy and Merchant Marine for sprayed zinc coatings are just additional reasons why civilian users of zinc may not be able to obtain all of the metal or pigment they would like to use.

THE NEW JERSEY ZINC COMPANY

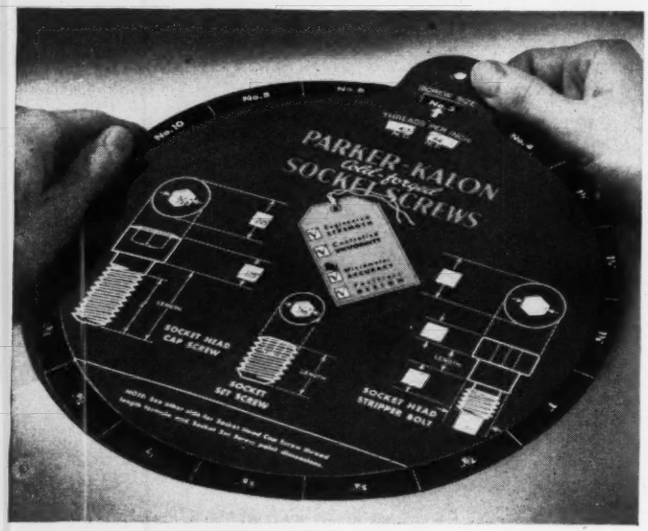
MANUFACTURERS OF THE FAMOUS HORSE HEAD ZINC PRODUCTS

1 HULL PLATES
2 RUBBER
3 PAINT
4 BRASS
5 CERAMICS
6 DIE CASTING
7 PHARMACEUTICALS
8 METAL SPRAYING
GALVANIZING
NICKEL SILVER

Free!

SOCKET SCREW DIMENSION FINDER

that will help you speed up work!



At A Glance – it gives designers, engineers and production men all important data on Socket Screws!

This unique chart will save you precious minutes and annoyance. A turn of the dial brings before you, in large, easy-to-read figures, all the important dimensions of the standard sizes of Socket Head Cap Screws, Stripper Bolts and Set Screws. On the reverse side you have a table of Set Screw Point Dimensions . . . Cap Screw Thread-length Formula . . . and other useful data. Ten inches in diameter, bright in color, this Finder won't get "lost" on a busy table. Hang it on your wall or drafting board by the metal reinforced hole.

SUPPLY IS LIMITED . . . so this offer of the Finder must be restricted to designers, engineers, drafting and production men in key positions who ask for a copy at an early date. Please be sure to attach coupon to your company's letterhead.

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Quality-Controlled
SOCKET SCREWS

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Send the Parker-Kalon Socket Screw Dimension Finder.
Name ..... Position .....
Company .....
Address .....
Make of Socket Screw we use .....

ASSETS to a BOOKCASE

Elements of Engineering Thermodynamics

By J. A. Moyer, J. P. Calderwood and A. A. Potter; sixth revised edition, published by John Wiley & Sons Inc., New York; 217 *pages,* 6 *by* 9 *inches, clothbound, available through* MACHINE DESIGN *for* $2.50 *postpaid.*

Although conforming to what has become practically a standard form of presentation of this subject, this book is outstanding because of the clarity and conciseness of its presentation. It is not mere coincidence that those problems in thermodynamics which are likely to cause the most difficulty in understanding are stressed to the utmost and in most cases are illustrated by sketches and schematic line drawings.

The general form of presentation followed in previous editions is also adhered to in this. However, in this new edition a chapter has been added on the applications of thermodynamics to compressed air, refrigerating machinery and air conditioning. The book can be highly recommended as a reference or a text to more advanced branches of the science.

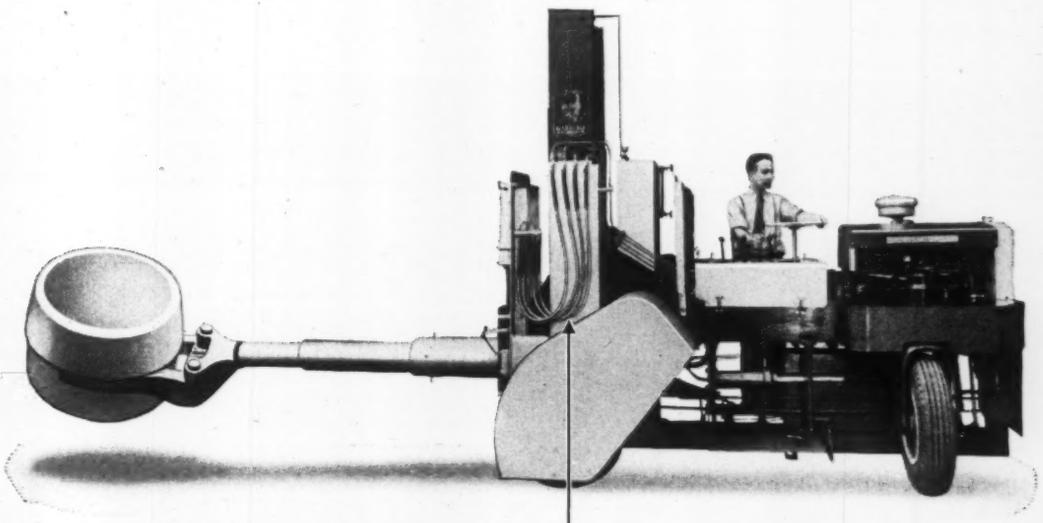
□ □ □

The Airplane and Its Components

By William R. Sears, Chief of Aerodynamics, Northrop Aircraft Inc.; published by John Wiley and Sons, Inc., New York; 75 *pages,* 6 *by* 9 *inches, clothbound, available through* MACHINE DESIGN *for* $1.25 *postpaid.*

As an introduction to the field of aeronautical engineering, this book should be of considerable interest to the many engineers who have recently had to turn to the design of airplane components. Written from an engineering point of view and amply illustrated, the text wastes no words in getting down to fundamentals. Problems of the aeronautical engineer—dependability, light weight and aerodynamic refinement—are stressed along with the descriptions of the various parts and their functions. Separate chapters are devoted to types of aircraft and typical airplanes; external airplane components including the wing, fuselage, empennage and landing gears; internal airplane components including control systems, heating and ventilating systems, electrical and hydraulic systems, armament and armor; noise reduction; radio and instruments; engines and propellers including descriptions of typical engines, superchargers, cooling, fuel and lubricating oil systems and engine installation.

Engineers not directly concerned with aircraft production but who desire more than the lay-

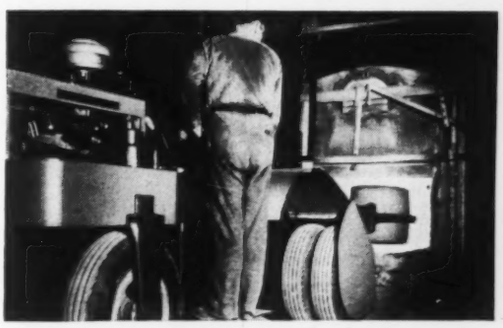


The "muscles" for this mechanical arm have to be more than strong

AMERICAN Seamless Flexible Metal Tubing, carrying hydraulic fluid to actuate the arm of this huge industrial truck, comes in for a tough assignment.

The truck cruises up to furnaces whose temperature is 2600°F., scoops up a molten mass of glass and transports it to rolling mills. The "muscles" are American Seamless—which conveys fluid at 1800 p.s.i. to lower and raise the heavily laden arm while being subjected to the high temperatures at the furnace mouth.

This rigorous service is typical of the jobs that industry has found for tough, pressure-tight connectors of American Seamless, and is typical also of the jobs Uncle Sam has selected for all the products of American Metal Hose. In fact, our government is currently using the major part of our production and will probably continue to do so until victory is assured.



Better Sight for Better Defense—In the famous Bausch & Lomb plants, essential optical instruments for defense work and for defense workers begin in flaming furnaces like this one. Here, a Howell industrial truck with arm actuated through sturdy American Seamless, quickly and efficiently handles molten glass, later to be converted into research instruments, lenses, etc. 42175

ANACONDA

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AMERICAN METAL HOSE BRANCH OF THE AMERICAN BRASS COMPANY • GENERAL OFFICES: WATERBURY, CONN.
Subsidiary of Anaconda Copper Mining Company • In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ontario*

WHOEVER heard of such a thing? But that was one of the requirements when this job was submitted to Phoenix. We were to design and produce a claw hammer forged from alloy steel, the claw to be so finely and accurately split that it would pull a needle driven into a board.

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Phoenix Products Mean Quality

man's superficial knowledge of airplane construction will welcome the brief and readable treatment of the subject.

□ □ □

Heating, Ventilating, Air-Conditioning Guide

Published by the American Society of Heating and Ventilating Engineers, New York; 1159 pages, 6 by 9 inches, clothbound, available through MACHINE DESIGN *for $5.00 postpaid.*

Containing 855 pages of technical data, the subject of heating, ventilating and air-conditioning is treated from the basic principles and theories, through the specification of parts and materials, to the design and installation of equipment. In this edition a new chapter entitled "Fundamentals of Heat Transfer" has been added. This includes basic equations for conduction, convection and radiation, as well as a detailed solution of a problem incorporating all three of these methods.

□ □ □

Plastics Mold Designing

By Gordon B. Thayer; published by American Industrial Publishers, Cleveland; 64 pages, 6 by 9 inches, clothbound, available through MACHINE DESIGN *for $2.50 postpaid.*

For the designer requiring a sound background knowledge of the possibilities and limitations of designing for plastics, this book fills a definite need. Information contained is practical and specific, and is presented mainly in the form of detailed descriptions of the design of the various types of molds, both compression and injection.

Of particular importance to the machine designer is a chapter on design procedure for molded plastic parts. Economical production can be assured by the application of accepted design principles that result in simplied molding procedures. The fundamentals underlying the design of threads, undercuts, corner construction and other molding operations are covered by practical examples.

Fourth edition of a comprehensive 224-page handbook "Molding Technic for Bakelite and Vinylite Plastics" has recently been published by the Bakelite Corp. The discussion is concerned with the important phases of molding processes and molding equipment generally employed in commercial production of molded plastic parts. A chapter on designing molded plastic parts will interest the engineer particularly. Sequence of steps involved in the creation of a design is outlined, taking into consideration functional, artistic, engineering and production requirements. The manual, which measures eleven inches by eight inches, is listed at $3.50.

PHOENIX DEFIES MOISTURE GHOSTS

Your hands are never dry. Perspiration stains ordinary tracing cloth, producing opaque spots, or "ghosts," that show on blueprints. Water splashes make even more disagreeable stains.

PHOENIX *Tracing Cloth withstands actual immersion in water for more than* 10 *minutes at a time without ill effects!* Perspiration will not stain it!

PHOENIX LESSENS SMUDGE GHOSTS

The improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

Result: Cleaner tracings and blueprints.

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Ordinary tracing cloths become scarred when erased. Erased spots produce ghosts on the blueprints.

PHOENIX has a durable drawing surface that reduces working scars to a minimum.

HERE'S A TRACING CLOTH *proofed against* MOISTURE GHOSTS

Perspiration stains and water marks hold no terrors for this improved tracing cloth—*and it holds pencil smudges or erasure scars at a minimum.* Now you can have clean tracings, in pencil or ink, free from these untidy "ghosts" that reproduce on blueprints!

The secret of this amazing performance lies in a remarkable new process that defies moisture, and gives PHOENIX an unusually durable working surface. You can use harder pencils with this improved cloth and get sharper lines with less tendency to smudge. Even 6H pencil lines show clearly, and reproduce strongly! Erasing does not mar the drawing surface; erased areas take pencil smoothly—and ink without feathering. The new white color and increased transparency provide excellent drawing contrast and produce strong blueprints.

Let PHOENIX speak for itself on your own drawing board. See your K&E dealer, or write for a generous working sample and an illustrated brochure.

K&E Phoenix

REG. U.S. PAT. OFF.

TRACING CLOTH

for pencil *and* ink

EST. 1867

KEUFFEL & ESSER CO.

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Victoprene Oil Seal made by Victor Manufacturing & Gasket Company, showing combination of felt washer and rubber-like synthetic sealing element.

The accuracy and dependability that won prominence for Victor Oil Seals in peace-time equipment enable them to contribute vital service to the Victory Program. The combination of the felt washer, to exclude grit, dirt and dust, and the rubber-like synthetic element, to guard against loss of lubricant, meets the toughest tests of planes, trucks, tanks, jeeps and other automotive equipment. The wicking of the oil-saturated felt provides a clean bearing point for the seal, and helps to retain the lubricant within the assembly. To protect bearings and to assure continued efficiency, make certain that there is a felt washer close to the sealing element. Please write, on your Company letterhead, for Data Sheets #6, "Felt and Lubrication," #11, "Annular Designing and Dimensioning," and the S.A.E. Sample Catalog. Experienced representatives are available if you would like personal advice.

American Felt Company

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General Offices: GLENVILLE, CONN.

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PRODUCERS OF FINEST QUALITY PARTS FOR OIL RETAINERS, WICKS, GREASE RETAINERS, DUST EXCLUDERS, GASKETS, PACKING FELTS, VIBRATION ISOLATING FELTS AND INSULATING FELTS

Does Centrifugal Casting Offer the Alternative?

(*Concluded from Page* 77)

the object is cast in one piece. Wall thicknesses of these hollow objects can be so controlled that the resultant casting weighs 80 per cent less than if solid. The possibilities represented by this development place it in a field belonging exclusively to the centrifugal casting process. By no other method of manufacture, with the possible exception of glass blowing into a mold, may hollow, one-piece parts be produced.

Representative of a few of the many alloys capable of being fabricated into parts by the centrifugal casting process are those included in the table. The bronze identified by Navy specifications 46M6f is a particularly strong and tough material with excellent wearing properties. It is used for bearings, shaft sleeves, etc. Gray iron is suitable for bushings, liners and machinery castings where ease in machining is desired and high strength or hardness is not essential. Despite its somewhat lower strength Ni-Resist possesses the desirable qualities of nonmagnetic properties, corrosion and heat resistance. In its corrosion-resistant properties it is frequently equal to that of the bronzes. Although its heat resistance is not the equivalent of the high nickel-chromium types, it is much superior to plain or low alloy cast iron.

Nonferrous Casting Alloys

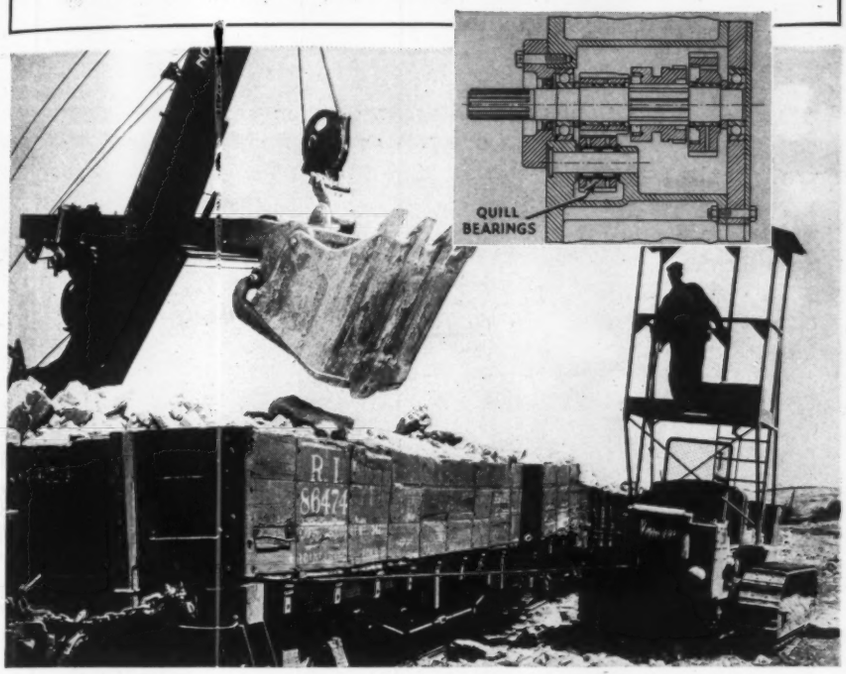
The general-purpose bronze listed is used for reciprocating pump liners, centrifugal pump shaft sleeves, hydraulic cylinder liners, propeller hubs, blades, gears, wormwheels, etc. It is not recommended for bearings or bushings or for applications subject to strong acid solutions. In many respects, aluminum bronzes are comparable to the manganese type. In addition, the properties of aluminum bronze can be varied considerably by heat treatment.

Including such alloys as Everdur and other tradename metals, the copper silicon alloy is notable for its high strength and excellent corrosion resistance. It is used for rolls, liners, sleeves and tubes. The monel metal alloy listed is known as the standard grade. Among its many applications are valve fittings, propellers and hubs, engine framing, expansion joints, shaft nuts, pump liners, paper mill rolls, etc. When cast by the centrifugal process, the resulting dense and uniform grain structure, free of metallurgical defects, actually increases the normal corrosion resisting properties of the metal.

MACHINE DESIGN acknowledges with appreciation the co-operation of the following companies in assisting in the preparation of this article: Shenango-Penn Mold Co., *Figs.* 1, 2, 3 and 4; Ampco Metal, Inc., *Figs.* 5, 6 and 7.

IN THE NEWS

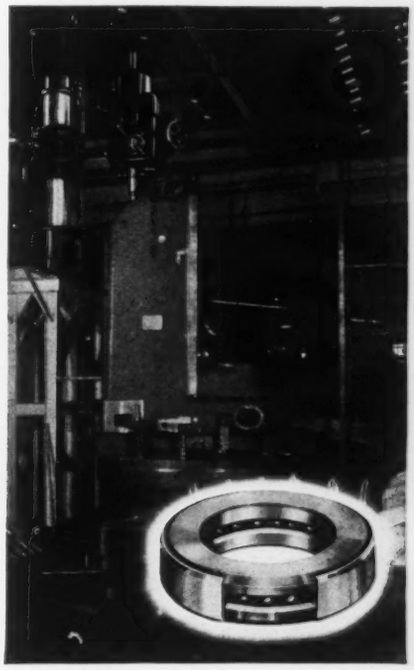
WITH BANTAM BEARINGS



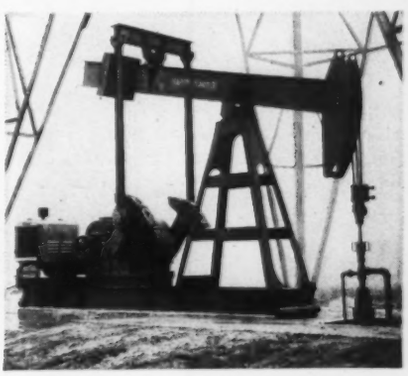
REPLACING A LOCOMOTIVE is all in a day's work for this worm drive towing winch used to move freight cars into position to facilitate even loading. Built by Willamette Hyster Company, it employs Bantam Quill Bearings in the idler gears of the transmission. As shown in the drawing, these compact Quill Bearings are particularly well adapted to the limited clearances available. And, in addition, the high load capacity of Quill Bearings aids the Hyster Winch in handling tough jobs efficiently and with minimum power loss.

IN THE GIGANTIC TASK of moving America at war—"Freightliners" are providing swift, safe convoy for raw materials, munitions, supplies and equipment. Built by Freightways Manufacturing Company, these dual trailer units use Bantam Quill Bearings for long, dependable service.

PROMPT DELIVERY OF SPECIAL BEARINGS is offered by Bantam because Bantam is tooled-up to manufacture made-to-order bearings with a minimum of delay. And the cooperation of Bantam's engineers is available to aid you in the design of such bearings. Or, if you have a standard application, remember that Bantam makes every major type of anti-friction bearing—straight roller, tapered roller, needle and ball. No matter how urgent your need or difficult your problem, for experienced engineering counsel or for prompt deliveries on essential jobs—TURN TO BANTAM.



THE BACKBONE OF INDUSTRY are machine tools such as the radial drill shown here, mounted on a platform for high altitude work in the plant of one of the Nation's largest machine manufacturers. Made by the Morris Machine Tool Company, this drill uses Bantam Radial Ball Bearings—a typical example of Bantam's service in the design and engineering of bearings for all types of applications.



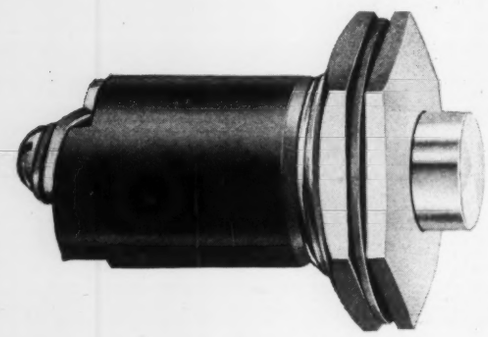
VICTORY OR DEFEAT in this war may depend on oil. Pumping units like this one, built by The Happy Company, are operating on a 24-hour basis to supply this vital source of power for American planes, tanks, and trucks. To assure efficient operation and long service life with a minimum of attention, Bantam Quill Bearings are used in equalizers, center iron saddles, other points of wear. The high unit capacity of these low-cost anti-friction bearings also helps simplify design.

BANTAM BEARINGS
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL
BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

New PARTS AND MATERIALS

Aircraft "Thumb" Switch

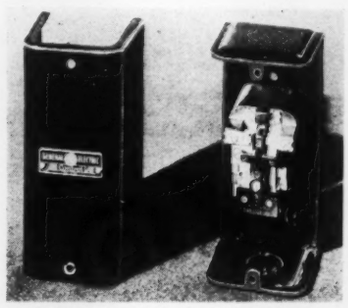
PRIMARILY for use on military aircraft, tanks, etc., a new "thumb" switch is being offered by the Regulator division, Square D Co., 6060 Rivard street, Detroit. Contact is made by pressing and holding the metal button. Upon release the circuit is immediately opened. The switch is also suitable for use as gun fire and turret control or any signal system where the power source is of low potential



up to 24 volts direct current. Operating button and flange are of metal with the switch body of bakelite. Enclosed electrical contacts are fine silver, single-pole, double-break. Designed for flush mounting to signal the position of doors, landing gears, brakes or other movable parts of commercial or military aircraft, the switch has an inductive rating of 15 amperes at 24 volts direct current, ample for handling small solenoids, control circuits, lights, etc.

Relay-Contactor Announced

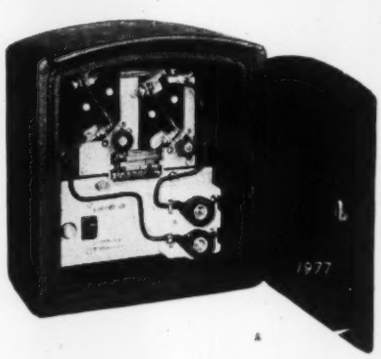
SUITABLE for controlling pilot circuits, as a fractional-horsepower motor starter or for use in conjunction with a magnetic switch controlling larger motors, heating or lighting circuits, or signal systems, General Electric Co. has made available its new magnetic relay-contactor either as a relaying unit or motor starter. Furnished in open form or enclosed in a general purpose housing, it is available in three contact arrangements—single-pole normally open, double-pole normally open, and double-pole, double-throw. Use of a U-shaped cover, allowing access to the front-connected terminals from three directions, simplifies wiring and servicing of the enclosed type. When the double-pole form is used with a momentary contact pushbutton station, undervoltage protection can be provided by the use of one pole as holding interlock in coil circuit. When used as a relay, the unit is rated at 10



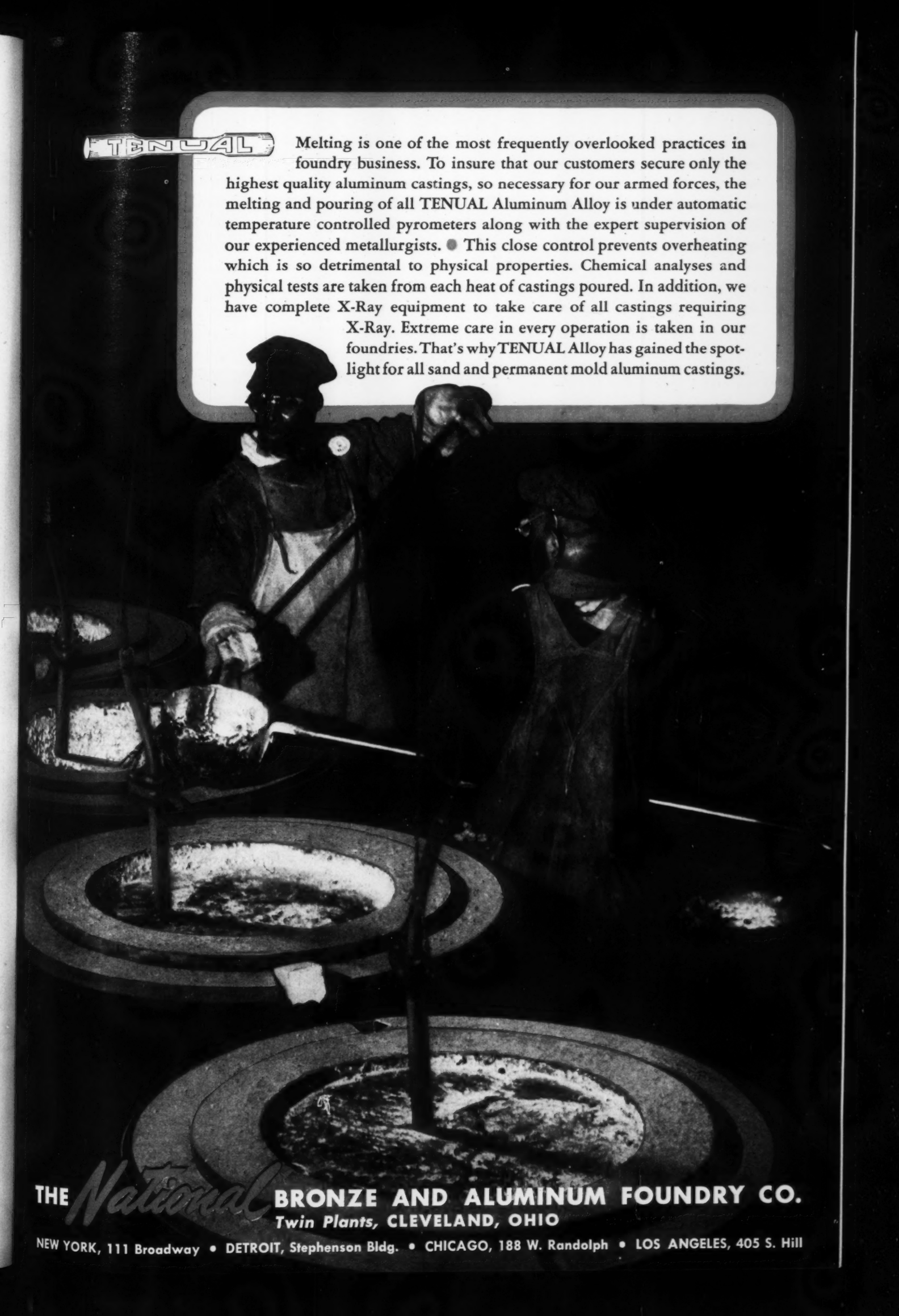
amperes; and when used as a motor starter, the normally open tips are rated ½ horsepower, 110 volts alternating current and 1 horsepower, 220 volts alternating current. Case is 3 x 2¾ x 6-1/5 inches.

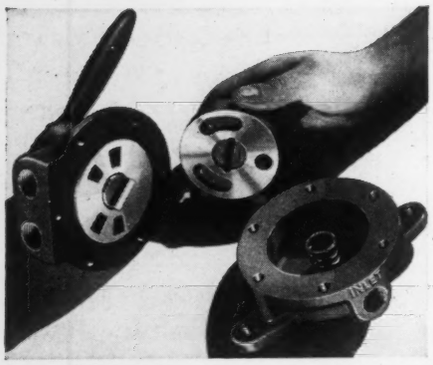
Control for Sirens

AS THE success of a siren depends upon raising and lowering of tones accomplished by a control turning the siren motor circuits on and off, it is important that the control be dependable. The coding control of Reynolds Electric Co., 2650 West Congress street, Chicago, is equipped with



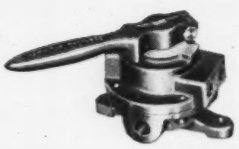
large silver contacts and a series of timing cams driven by a synchronous motor, shaped and arranged to control the number of signals and the desired time by automatically turning the motor sirens on and off. Parts are mounted in welded steel frame, assuring alignment of parts. This control is designed for 660 watts per circuit for 110-volt, 6-cycle current, to operate two signals

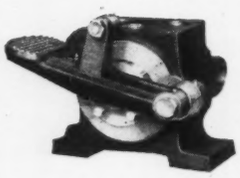

TENUAL
Melting is one of the most frequently overlooked practices in foundry business. To insure that our customers secure only the highest quality aluminum castings, so necessary for our armed forces, the melting and pouring of all TENUAL Aluminum Alloy is under automatic temperature controlled pyrometers along with the expert supervision of our experienced metallurgists. This close control prevents overheating which is so detrimental to physical properties. Chemical analyses and physical tests are taken from each heat of castings poured. In addition, we have complete X-Ray equipment to take care of all castings requiring X-Ray. Extreme care in every operation is taken in our foundries. That's why TENUAL Alloy has gained the spotlight for all sand and permanent mold aluminum castings.
THE National BRONZE AND ALUMINUM FOUNDRY CO.
Twin Plants, CLEVELAND, OHIO
NEW YORK, 111 Broadway • DETROIT, Stephenson Bldg. • CHICAGO, 188 W. Randolph • LOS ANGELES, 405 S. Hill

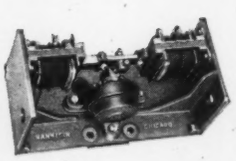


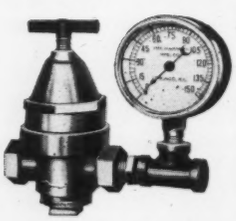
VALVES YOU CAN INSTALL AND FORGET

Hannifin "Packless" Air Control Valves provide the positive, accurate control of air operated equipment essential to modern production operations, with a simple, effective design that assures long service with minimum attention. The Hannifin disc-type design has no packing—and no leakage or packing maintenance troubles. The bronze disc that controls air flow is ground and lapped to form a perfect seal with the seat. Wear is negligible, yet if necessary after long service, simple re-lapping restores the original efficient seal.









A complete range of choice is available in hand and foot operated models, adaptable to every air control need. Hannifin Valves are made in 3-way and 4-way types for various standard cycles of operation: hand control valves; duplex valves for control of two double-acting cylinders; spring return for instant reversal upon release of foot pedal or hand lever; heavy duty rotary valves; electric models for remote control; manifold type for centralized control of several units; pressure regulating valves.

Write for Valve Bulletin 57-MD with complete data on all types.

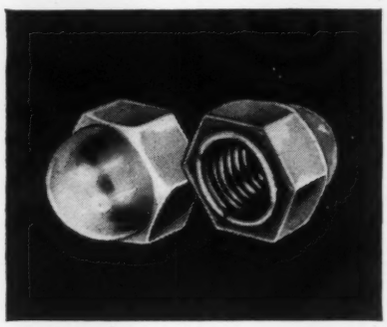
HANNIFIN MANUFACTURING COMPANY
621-631 South Kolmar Avenue • Chicago, Illinois

HANNIFIN
"PACKLESS" AIR CONTROL VALVES

which are started with pushbutton and cut off automatically. One signals a series of alarms in 15 cycles of eight seconds each for a period of two minutes. The other signals a steady "all clear" siren blast for two minutes. The cabinet of the control is weatherproof, and has a door lock with fuse block and pushbutton. Size is 5 x 6½ x 4 inches.

Nuts Available in Cap Shapes

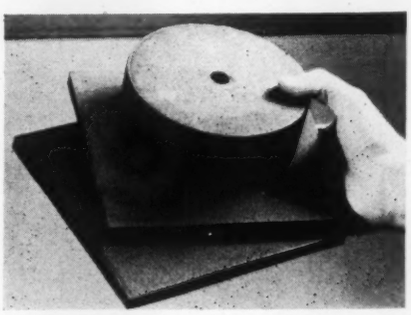
CAP nut shapes made to customers' specifications are now being furnished by An-cor-lox division of Laminated Shim Co. Inc., Glenbrook, Conn. There is a wide choice in materials for the nut body, also considerable variation in the metal-



lic composition of the locking ring insert. All standard sizes, measured by bolt diameter dimensions, are available, with thick or thin walls. Cap nuts are of all-metal construction and self-contained, the locking ring being integral with the nut body.

Hard Sponge Rubber Produced

PRODUCTION of hard sponge rubber by B. F. Goodrich Co., 1247 South High street, Akron, O., comes as an innovation in synthetic rubber manufacturing. Laboratory tests show that this new rubber possesses the properties and general



characteristics of the regular Ameripol compound, produced by the company, in its resistance to action of oils, greases and other solvents which are natural enemies of rubber. Light in weight, thus giving a high degree of buoyancy, the material can be sawed or drilled, has good acoustic

AMERICAN
FLEXIBLE COUPLINGS

MACHINE DESIGNERS *Specify*
AMERICAN FLEXIBLE COUPLINGS

THE rugged simplicity of American Flexible Couplings at vital points of power transmission plus the wide variety of types, kinds, and sizes available, provides Machine Builders with flexible drive units to meet their most exacting conditions.

Get our new catalog which lists and describes all types and sizes of American Flexible Couplings . . . The request on your letterhead will bring your copy, no obligation whatever.

ZURN

AMERICAN FLEXIBLE COUPLING CO.
DIVISION OF
J. A. ZURN MFG. CO., ERIE, PENNA.

SMALL GASOLINE MOTORS HELP TO KEEP FIGHTING MEN

• Military men state that cleanliness is a basic requirement — essential to morale and health. Mobile units—on which is mounted equipment powered by Briggs & Stratton gasoline motors, for heating water in volume—provide "showers" for men doing field service, and in temporary camps — also used to distill water for cooking and medical purposes — and as sterilizing and disinfecting units.

Fit!

THE ENTIRE PRODUCTION FACILITIES of our company are assigned to the war program. If your equipment is serving the army, navy or air forces of the United Nations, or is in an "accepted" essential industry — and you require gasoline motors in our range of from ⅔ to 6 H. P. — we will strive to serve you.

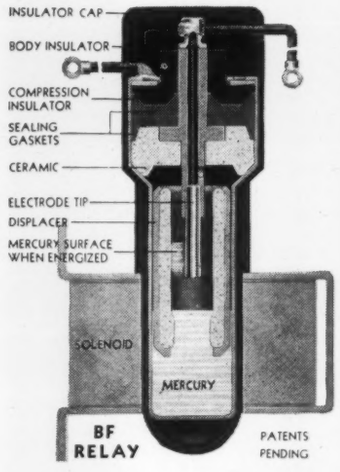
The service of Briggs & Stratton 4-cycle, air-cooled gasoline motors, over a million and a half produced to date, can be extended materially by proper care, and by periodical inspection for damaged or worn parts needing replacement. Equipment dealers and Authorized Service Stations everywhere are ready to help "keep 'em running."

BRIGGS & STRATTON CORP.
Milwaukee, Wis., U. S. A.

properties, and does not show signs of injury after prolonged subjection to heat of 158 degrees Fahr. The rubber can be produced in slab or molded form. Compression tests have proved that a mechanical pressure of 225 pounds per square inch will not break down or harm its cellular makeup. Among known uses of this hard sponge rubber is its suitability on specialized insulating and float jobs where an oilproof, waterproof and acidproof material is required.

Blackout Mercury Relays

FOR blackouts and defense applications Durakool Inc., 1010 North Main street, Elkart, Ind., has made available its new quick-acting mercury relays, designated as BF and CF. Circuit is made and broken in a hermetically-sealed chamber under hydrogen at high pressure. The relays cannot be affected by dust, dirt, moisture or corrosion, and are not subject to arcing or pitting contacts. Having low contact resistance, the relays are explosion proof. When coil is energized the plunger is pulled down and displaces the mercury, causing the mercury to rise in the steel chamber until contact is made with electrode. Capacity of the BF relay is 30 amperes, and of the CF type, 65 amperes.



High Impact-Resistant Plastic

DESIGNATED as phenolic resin XM-15000, Bakelite Corp., unit of Union Carbide & Carbon Corp., 30 East Forty-second street, New York, has developed a new impact-resistant phenolic molding plastic to meet needs of industry for a high impact-resisting molding material which can be preformed on automatic tabletting machines. When molded the material has approximately twice the shock resistance of general-purpose phenolics. Water resistance is also good. Physical properties of the molded test pieces are as follows: Specific gravity, 1.36; weight per cubic inch, 22.2 gm; tensile strength, 5000-5800 pounds per square inch; and modulus of elasticity, 10-13 x 105 pounds per square inch. This type of material is recommended

PRESTITE

CAN *REALLY* TAKE IT*

Basically Prestite is a porcelain. But it is a vastly superior porcelain. Because of its ability to withstand both physical and thermal shocks, many manufacturers have found that Prestite is a worthy substitute for priority-pinched metals and plastics.

* Tests show that Prestite will withstand pressures of 45,000 pounds per square inch.

Like cast metals, it can be cored for complicated internal cavities. Prestite retains its dimensional accuracy, regardless of size. Neither heat nor cold will cause it to flow or warp.

* Dimensional accuracy is guaranteed not to exceed $\pm \frac{1}{64}$" per inch. In most cases tolerances will be even closer.

Proof of its ability to stand up under punishment is its successful performance in such unusual applications as valve seats for high-speed pumps, thread guides, sand blast nozzles, bus separators, third rail insulators.

* Repeated laboratory tests show that Prestite has a tensile strength of 5,000 pounds per square inch, and a cantilever strength of 1,224 pounds per square inch.

Prestite will not weather, deteriorate or discolor. Completely inert chemically, oils, alkalis, and acids other than hydrofluoric can not harm it. *Flashovers will not track or char it.*

* Although Prestite is naturally white, it may be colored partially or completely by any of the available industrial ceramic glazes.

This ceramic plastic . . . Prestite . . . may be a better answer to many of your design problems, on the basis of both cost and performance. Investigate! Your Westinghouse Representative will be glad to help you. Ask him for all the facts about Prestite. Or, write direct to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N. J-05134

Westinghouse

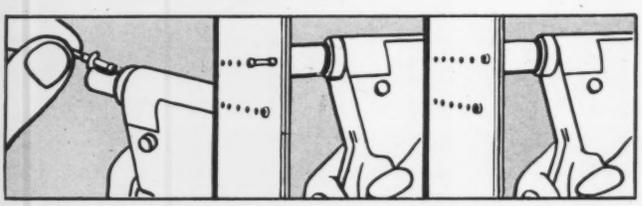
PRESTITE

Cherry Rivets

Here's a one man rivet

for the hard-to-get-at jobs

Cherry Blind Rivets—flying on American fighter planes on every front—may be just as important for your product. They are true rivets having brazier or countersunk head, and hollow shank through which a double-headed mandril passes.



Projecting mandril of self-plugging Cherry Rivet is placed in head of gun. The rivet extending from head of gun is placed in the work. Pneumatic pull on mandril forms head on the blind side of the rivet, breaks the mandril on the near side and releases gun.

When the rivet is applied with either a hand-operated or pneumatic gun, the mandril forms a tulip head on the blind side. In the hollow type, the mandril flies out of both ends when applied. In the self-plugging type, the mandril automatically and permanently plugs the rivet. The positive mechanical action resulting from high pressure application assures the formation of a satisfactory head on the blind side.

From left to right, the hollow type with brazier and countersunk heads—the self-plugging type with both styles of heads. All are applied with hand or power guns. G-15 Power Gun shown above.

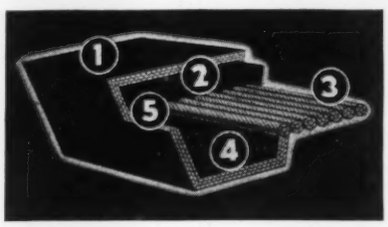
MANUFACTURED UNDER U. S. PATENT NO. 2,183,543

Cherry Rivet
COMPANY
LOS ANGELES, CALIFORNIA

for use where molded parts are to be subjected to temperatures up to 300 degrees Fahr. (149 degrees Cent.). Electrical properties are: As is, dielectric strength at 60 cycles, 110-125 volts per mil; if preheated for 30 minutes at 220 degrees Fahr., the dielectric strength is 250-275 volts per mil.

Cord Multiple V-Belt

SHEATHED with a tough, black cover for long wear, more uniform pull and higher resistance to heat, oil and other enemies of long belt life, the new multiple V-belt announced by Goodyear Tire & Rubber Co., Akron, O., takes advantage of the fact that the tough, long-wearing compounds have always been black in color because of the use of black carbon stocks. More uniform pull and better

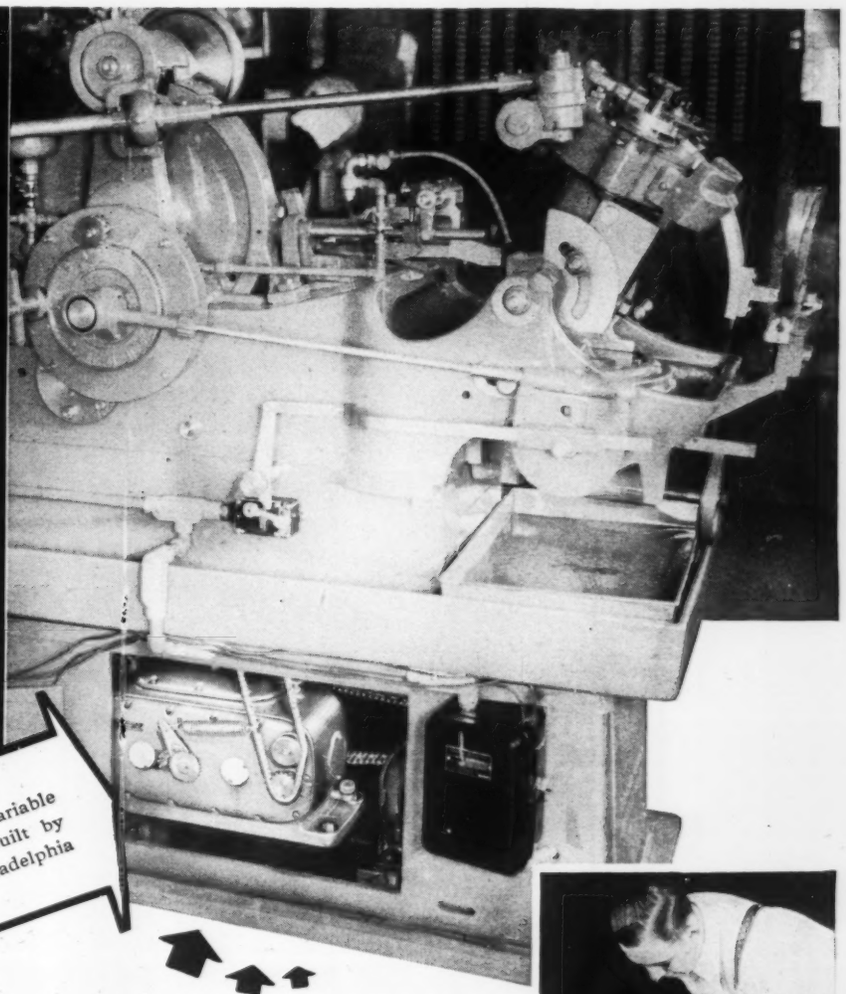


balanced performance is obtained due to the fact that it is possible to build the new black cover with more consistent coefficient of friction, essential to a balanced drive. In addition the cord construction of the belt concentrates the load-carrying cords in the neutral axis where all pull evenly, without stresses. The belt, which is available in all standard cross-sections and lengths, in sets, precision-matched under operating tensions, can deliver higher efficiency on multi-V drives.

Moisture-Resistant Switch

METAL-CLAD, sensitive, snap-action switches, announced by Mu-Switch Corp., Canton, Mass., consist of a standard switch, in accordance with Army Air Corps specification 94-32249, with a special overtravel plunger mechanism mounted in a zinc or aluminum die-cast housing. A large molded neoprene bellows seal around the operating plunger will withstand most oils, moisture, dust, soap, fruit juices, etc. A gasket, also of the same material, is used between body and base of die casting, and mounting bolts are sealed through use of pure lead washers. Switch can be operated through extremes of temperature from minus 10 degrees Fahr. to plus 150

PRODUCTION INSURES VICTORY! • • • —



P.I.V. Gear makes a positive, compact, variable speed drive for bevel gear generator built by Bilgram Gear & Machine Works, Philadelphia

INSTANT... Accurate Speed Changing Is Vital to Highest Machine Output!

By incorporating the Link-Belt P.I.V. Gear into the machines you design, a higher performance efficiency is certain to be achieved. Instantly — while in operation — the machine speed can be changed to the exact rate desired, by a simple twist of the wrist. Thus, for any operation, the most efficient speed can be predetermined and then instantly secured without any time wasted.

Investigate this all-metal chain gear — learn about its positive, non-slip, tooth-to-tooth engagement—study its compact design and wide range of sizes and types. Ask for Book No. 1874—it explains the P.I.V. Gear in detail—write for your copy today!

Available in horizontal and vertical mountings . . . motorized and gear set models . . . automatic, vernier, manual, direct, or remote control.

LINK-BELT COMPANY, Philadelphia Plant, 2045 West Hunting Park Ave.
Chicago, Indianapolis, Atlanta, Dallas, San Francisco, Toronto. Offices, warehouses and distributors in principal cities

Leading Manufacturer of Mechanical Transmission Equipment—Silent and Roller Chains . . Speed Reducers . . Speed Variators . . Roller, Ball and Babbitted Bearings . . Collars . . Couplings . . Base Plates . . Take-Ups . . Clutches . . Gears . . Sprockets . . Hangers . . Shafting . . Pulleys, etc. 8816

LINK-BELT P.I.V. GEAR

POSITIVE INFINITELY VARIABLE SPEED CONTROL

HANSEN *Push-tite*
AIR HOSE COUPLINGS

Regardless of your air problem in the plant, Hansen *PUSH-TITE* air hose couplings are the answer. No matter how tough the going—Hansen *PUSH-TITE* air hose couplings will not leak under any pressure. There is no wasted air due to leakage and no wasted time and effort because *PUSH-TITE* air hose couplings are fast on the trigger—a simple push of plug into socket, it is connected air tight and air is automatically turned on, a slight pull, air is automatically turned off and coupling is disconnected. Speeds up production tremendously, no twisting or turning of parts—to connect or disconnect and the complete swivel action eliminates the customary problem of "kinks" in the hose.

Hansen *PUSH-TITE* air hose couplings are widely used on air, oil or grease lines, working efficiently on all three. Send for free catalog.

Hansen MFG. CO.
INDUSTRIAL AIR LINE EQUIPMENT
1786 E. 27TH STREET • CLEVELAND, OHIO

degrees Fahr. Unit can be completely sealed by use of a sealing compound on the conduit connection, which is tapped for a ½-inch pipe thread. Electrical rating of switch is 25 amperes at 28 volts direct current, 17 amperes at 125 volts alternating current, 8.5 amperes at 250 volts alternating current, 3 amperes at 460 volts alternating current, and 2 amperes at 600 volts alternating current. It is also rated at ½ horsepower at voltages from 115 to 460 volts alternating current. Wiring connections can be supplied normally open, normally closed, or single pole, double throw. Operating pressures are from 6 to 28 ounces. Amount of pretravel and overtravel can be adjusted to meet requirements. Normal pretravel, however, is approximately .01-inch with an overtravel of ¼-inch.

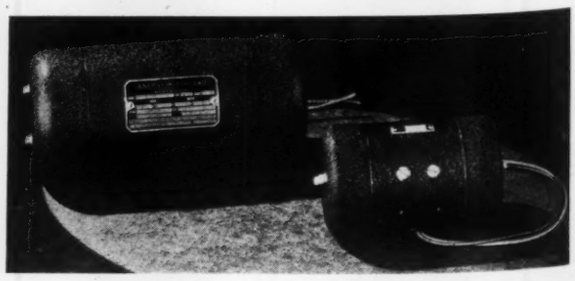
Thin Slot Insulations

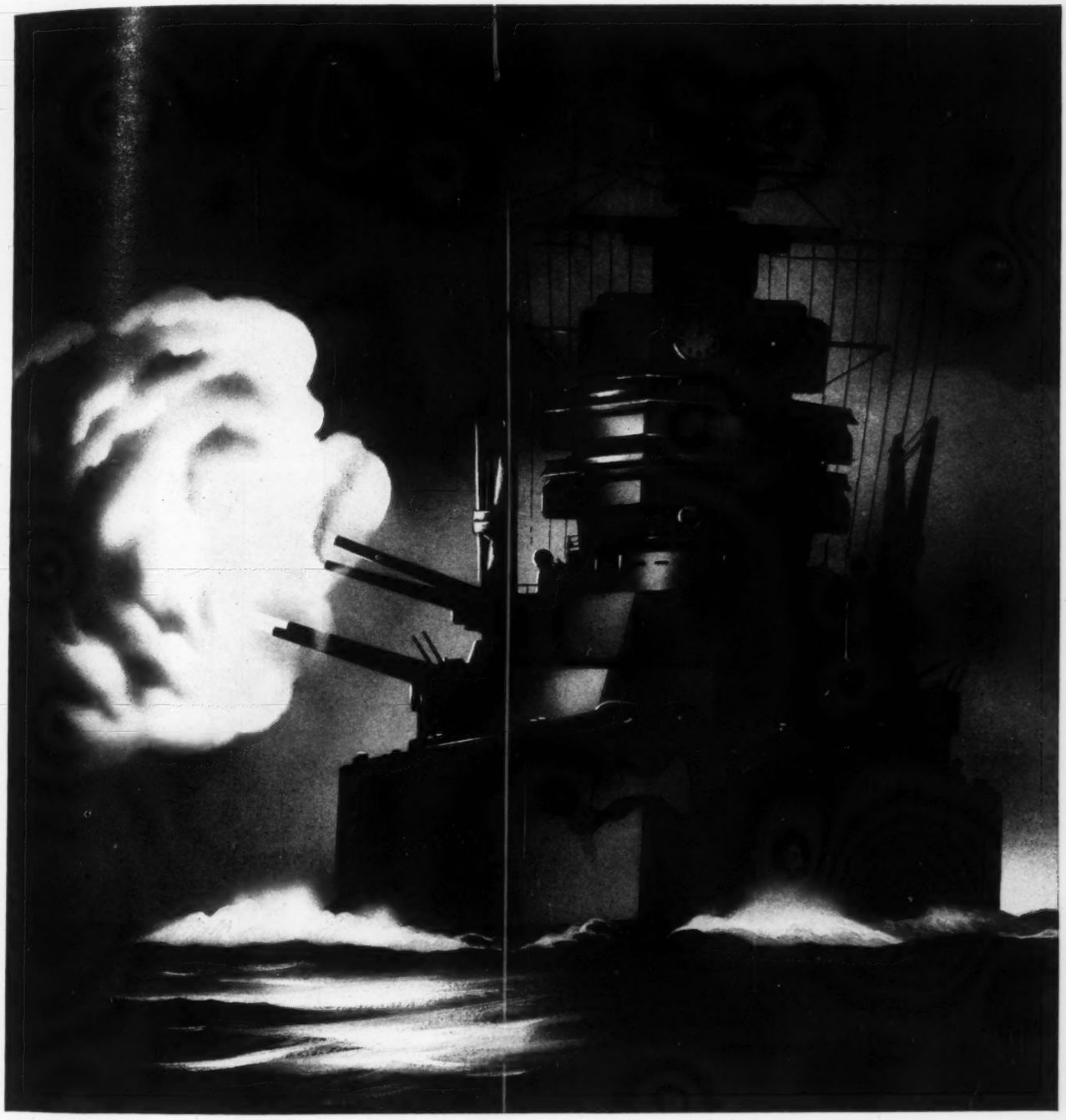
DEVELOPED by Irvington Varnish & Insulator Co., Irvington, N. J., new thin types of slot insulations possess ample strength and toughness as protection against mechanical stresses. They have high dielectric strength and exceptional heat resistance, and can be used in confined or limited

space. The insulation consists of papers coated with resin, or bonded by means of a plastic insulator, to cambric, silk or Fiberglas. The bonded insulations have high moisture resistance. Available in sheets and also tape form, in thicknesses of .006 to .016-inch, ready to be cut into slot strips, the insulation is flexible and easy to form.

Communication System Dynamotor

FOR communication and other service in aircraft, tanks and mobile field equipment, General Electric Co. has announced its new line of dynamotors which raise battery voltage to radio transmitter or receiver voltages. The new line comprises five types of dynamotors, ranging from 25 to 600 watts in output, and from 3 to 31 pounds in weight. Other





MOLYBDENUM ENLISTS FOR THE DURATION

The enormous increase in requirements of molybdenum has necessitated the War Production Board Order M-110, placing molybdenum consumption under allocation control...Our metallurgical research staff is fully engaged in war work. At our mine, mill and converting plant, every effort is being made towards maximum production.

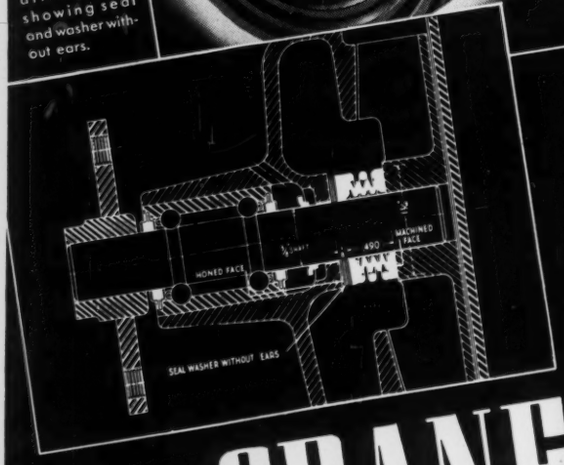
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • CALCIUM MOLYBDATE

Climax Molybdenum Company
500 Fifth Avenue • New York City

MOLY

NEW
WATER
PUMP
SEAL

John Crane Bellows seal and washer, without driving well, showing seal and washer without ears.



By JOHN CRANE

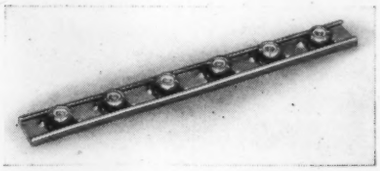
History—is written by the new John Crane Bellows Seal—nothing like it has ever been made before . . . Exclusive features! . . . Record-breaking performance under severe pressures, temperatures and fluids . . . Send your blue-prints and operating conditions. Ask for literature.

CRANE PACKING COMPANY, 1800 Cuyler Ave., Chicago
CRANE PACKING COMPANY, Ltd., Hamilton, Ontario, Canada

features of the unit are Formex wire insulation, lightweight, and reliability under rigorous conditions. Objectionable alternating-current ripple is kept at a value which requires a minimum of filter to provide satisfactory operation of the communication equipment. Dynamotor commutators are cut and undercut so that commutation will meet rigid standards. End caps are formed aluminum or steel covers, fastening to the high-pressure cast aluminum or steel end shields to keep out dust and dirt. Cartridge-type brush mechanisms are used, the brush holders being anchored in the castings.

Self-Locking Nuts in Strips

WIDELY applied in the aircraft industry, Elastic Stop Nut Corp., 2332 Vauxhall road, Union, N. J., is offering its new line of gang channel nuts. Factory assembled, the nuts are for applications where a multiple, self-locking bolted fastening is desired. The strips can be riveted or otherwise fastened to structures where they are to be used, and consist of specially designed stop nuts, with four lugs at the base installed at specified intervals in a metal channel strip which is preformed to accommodate the nut lugs under longi-



tudinal flanges. The channel strip is pierced for the required nut size and spacing, and nuts are held in place by dimples in the channel, tolerances permitting them to be virtually self-centering. Locking action is obtained with a vulcanized red-fiber collar which resists the entry of the bolt. This action forces nut outward, creating a constant metal-to-metal pressure-contact throughout the threads of nut and bolt, taking up all axial play and creating a cushion against vibration stresses and impact. Although gang channel nuts are permanently mounted, it is possible to remove or replace individual nuts if necessary. These nuts are available in standard six-foot straight lengths in a wide variety of nut sizes, thread systems, spacing materials and finishes.

Sensitive Bimetal Developed

AN IMPORTANT contribution to thermostatic bimetal is the development of W. M. Chace Co., Detroit. Through the use of new alloys, giving increased sensitivity, it is claimed that a reduction up to 40 per cent in weight and mass of thermostatic bimetal element is made possible. This reduction in size of element not only effects a saving in the amount of material in the thermal element, but also makes possible the use of smaller mounting space. In aircraft production particularly, and

BLUEPRINTS must be clear...

The Coordinating Link in Mass Production

Between purchasing agent and lathe operator, between the engineering department, management and the assembly line, there is one coordinating link—Blueprints. Blueprints chart the efforts and the energies of all.

Now, with production in high gear, with every plant running at full capacity, the burden on your Blueprinting Department is doubled and redoubled. Now, more than ever before, you need machines that not only can "take it,"* but which will protect hard-working tracings while operating at top speed. Now is the time to secure the advantages of Paragon-Revolute Coordinated Blueprinting Equipment.

What the Revolute 3-H Offers You

The Revolute 3-H Automatic Blueprinting Machine makes "*all three*"—Blueprints, brown prints, and white prints—automatically at maximum speeds.

The Revolute 3-H makes them in *only two operations*—feeding and trimming. Exposure, development, washing, drying, and rolling up all performed automatically.

No static is created in the Revolute Printer to interfere with handling of tracings. This is because there is no friction between tracings and contact glass.

The Revolute 3-H also offers: *Accessibility* for cleaning and maintenance; *Drying Control*—prevents wavy edges; *Non-slip Wind-up*—prevents tattered edges on finished prints; *Automatic Temperature Control*—individual switches on each drum not necessary—no knobs to turn heat up or down manually.

***Three types of light source* are available in the 3-H:**

1. *Standard Carbon Arc Lamps* for moderate speeds up to fifteen feet per minute.
2. *Special High Power Carbon Arc Lamps* for high speed requirements. Comparative tests show the 3-H with these lamps to be the FASTEST machine on the market.
3. *New Quartz High Pressure Mercury Vapor Lamp* for those who prefer this type of light. The 3-H is admirably suited for this lamp because the direct light can be used from all sides since it is located *inside* the revolving Pyrex glass cylinder.

PARAGON-REVOLUTE CORPORATION

ROCHESTER, N. Y.

A Print for Every Requirement

Whether you want Blueprints, Brown Prints, White Prints, Contact Photographic Prints, or Reproduced Tracings, you will find an answer in Paragon-Revolute Coordinated Blueprinting Equipment. *Complete Contact Coverage* is offered.

**See the list of firms on Page 32 and the inside rear cover of the new No. 1041 Catalog. The continued purchases of Revolute 3-H Automatic Blueprinting Machines by such concerns have proven the dependability of such equipment, and show that the 3-H can "take it."*

PARAGON-REVOLUTE CORP.
Dept. 6-D, Rochester, N. Y.

Gentlemen:
Please send me a copy of the new Paragon-Revolute General Catalog No. 1041.

Name.....

Company.....

Address.....

What Engineers Say About:

PLASTICS IN ENGINEERING

By John Delmonte

●

". . . should be on the 'must' list of all engineers".

—G. M. Kline
U. S. Bureau of Standards

" . . . the author is at his best in outlining the procedure to be followed in the development of a practical design."

—F. L. Yerzley
E. I. DuPont de Nemours & Co.

" . . . it is of vital importance that the useful properties as well as the limitations of plastics be recognized in design work."

—H. H. Ashinger
Westinghouse Electric & Mfg. Co.

" . . . a valuable contribution to the plastics industry".

—H. D. Payne
Chicago Molded Products Corp.

" . . . well planned and well organized work on plastics and their fabrication. It should be worth the while of any engineer who has the problem of choosing and designing for plastics."

—C. W. Blount
Bakelite Corp.

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●

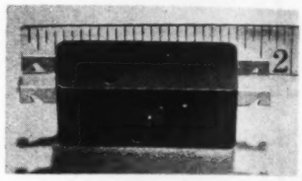
MACHINE DESIGN

Book Department
PENTON BUILDING CLEVELAND, OHIO

elsewhere where minimum weight and limited mounting space are factors, such reduction in size of element has many advantages.

Smallest Switch for Aircraft

ANNOUNCED by the industrial control division of General Electric Co. is a new switch for use in aircraft applications where space is limited and vibration conditions are severe. Believed to be the smallest switch of its type in the world, this "switchette" weighs only 9 grams and is designed to meet Air Corps requirements. Operated by a lever, bellows, or other actuating means by movement of a spring-return button in the housing, the switch is 1¾-inch long, 19/32-inch deep and ½-inch wide. Contacts are arranged for single-pole normally open, single-pole normally closed, or single-pole double-throw operation. Each form is available with a contact air gap of .01, .02, or .03 inch.



Light Weight Aircraft Rheostats

FOR aircraft and ordnance use where durability to withstand bomb and gunfire concussions as well as dependability to meet conditions of high humidity and temperature extremes are prime essentials, the International Resistance Co., 401 North Broad street, Philadelphia, has introduced its new type of IRC all-metal rheostat. The new unit embodies only minor changes from the lightweight metal construction of the company's line of rheostats. Instead of ceramic insulators, the new type has bakelite insulators; in addition to being lighter in weight, it has a 50 per cent lower temperature rise for equal size in other types; and it is available in both 25 and 50-watt sizes.

Controls for Pumps

CONTROLS for pumps and air compressors have been designed by Penn Electric Switch Co., Goshen, Ind., for service from 3 to 200 pounds per

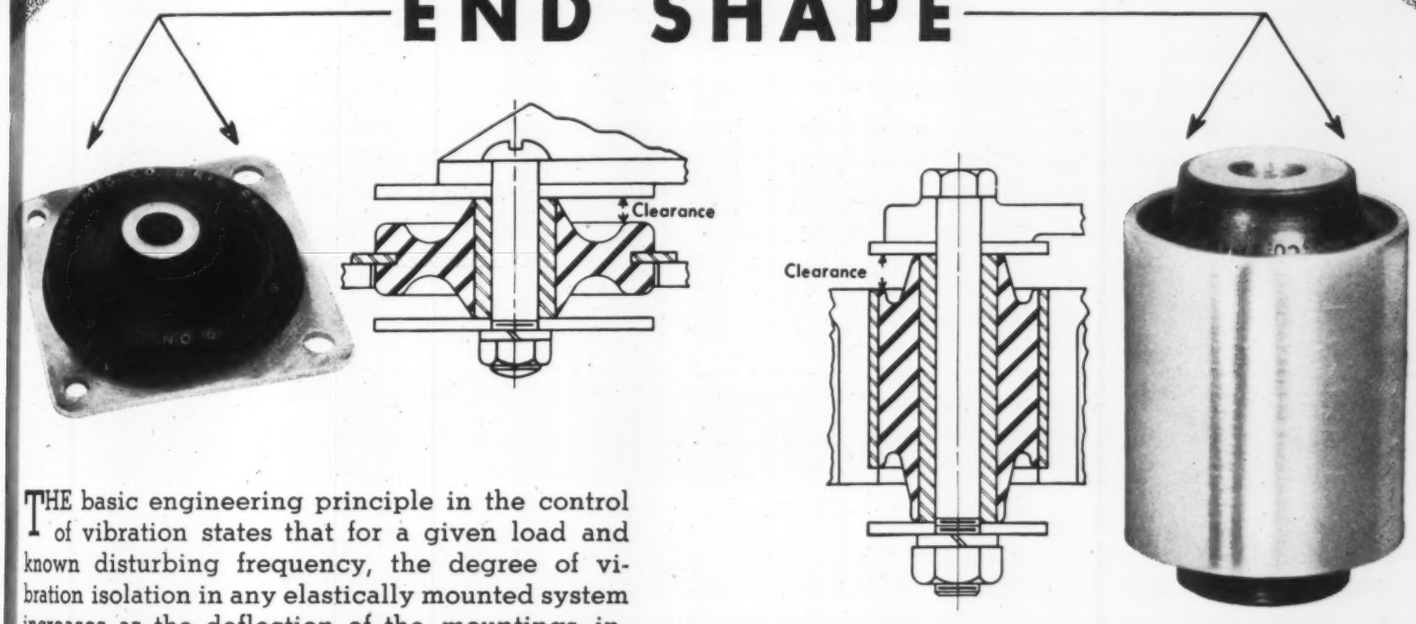
ADVANCED DESIGN FEATURES OF LORD MOUNTINGS

LORD BONDED RUBBER

make possible Efficient Vibration Control

Feature No. 1

END SHAPE



THE basic engineering principle in the control of vibration states that for a given load and known disturbing frequency, the degree of vibration isolation in any elastically mounted system increases as the deflection of the mountings increases. As a result of the practical application of this basic principle to Lord Bonded Rubber Mountings, many advanced design features have been developed. One of these important design points is the end shape which is clearly brought out in the illustrations above and is one of the outstanding characteristics of Lord Mountings.

The Lord Mounting end shape design—

1. Permits adequate deflection in shear under load.
2. Allows sufficient clearance for free shear movement in the vibratory range.
3. Throws flexing action away from the bond into the rubber body, and
4. Eliminates any possibility of stress concentration along the rubber-to-metal bond, thus
5. Multiplying the useful life of the mounting.

Lord Bonded Rubber Mountings are made in Plate Form for supporting loads from a few ounces up to 300 pounds each, and in Tube Form for loads up to 1500 pounds each. Complete description of these mountings, including load ratings and other operating characteristics are given in Bulletin 104. Vertical Snubbing Mountings of the same types are produced for installations where heavy shock loads are encountered as well as vibratory forces. These mountings are described in Bulletin 103. Copies of this literature will be sent on request.

Experienced Lord vibration engineers are available for consultation on proper vibration control for any type of mechanical equipment.

LORD MOUNTINGS

Control Vibration— through adequate flexibility in direction of vibratory thrusts and stability in other directions.

Eliminate Fatigue—through reduction of repeated stresses.

Speed Production—through elimination of close machining of the mounting base or mounting points.

LORD MANUFACTURING COMPANY . . . ERIE, PA.

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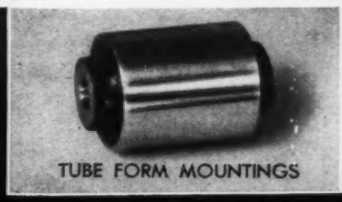
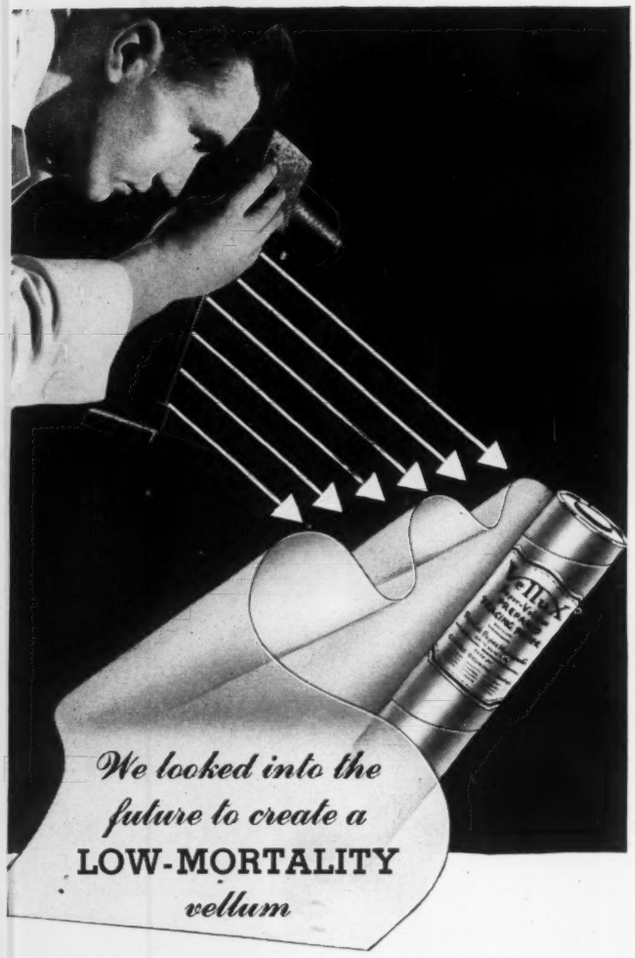
LORD
BONDED RUBBER
SHEAR TYPE
VIBRATION
MOUNTINGS



IT TAKES RUBBER IN SHEAR TO ABSORB VIBRATION



MOST vellum tracing papers look good at a glance. But the real test of vellum value is in what happens weeks—months or years later. Does the vellum have high or low "mortality"? Will it turn yellow? Will it become brittle? Will it go to pieces in handling or in the file?

Applying research to this problem, Bruning created—20 years ago—a vellum which has never been surpassed for long life and durability. It is Bruning Vellux—proof against *all* the attacks of time. It keeps its excellent printing qualities indefinitely... does not turn yellow. It does not grow brittle or crack. And, while many another brand of vellum tracing paper has come and gone, Bruning Vellux has retained highest standing in the drafting rooms of the Nation.

Research is a process that goes on *continually* at the Charles Bruning Company. Important improvements in sensitized paper, drawing materials, and drafting equipment have made Bruning an unquestioned leader. That's why you'll find—as thousands of others have found—that it pays to deal with a company which *concentrates on doing a better job for the customer.* Charles Bruning Company, Inc.

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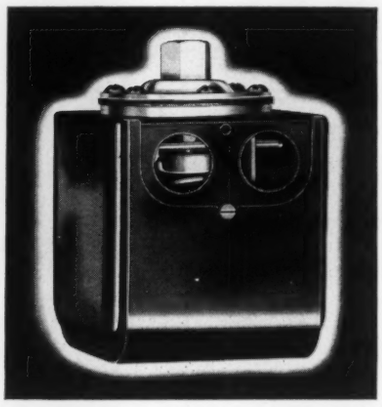
SPEEDS—SIMPLIFIES—AND PROTECTS A NATION'S DRAFTING

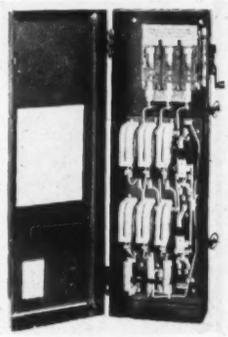
square inch pressure. Built in single and double pole designs, these controls—Series 114 and 116—are available with or without mechanical two-way release valve. Some of the outstanding features of the controls are: Double-break, electrolytic silver contacts actuated by the "V-over-roller" mechan-



ism; both movable and stationary contacts are readily accessible and easily replaceable without dismantling any part of control; easy adjustment of both range and differential setting; wiring terminals are easily accessible and generous barriers enable easy installation of wiring and also prevent loose strands from shorting.

Magnetic Reversing Starters

ALTERNATING-CURRENT combination magnetic reversing starters for full-voltage starting and reversing of squirrel-cage induction motors have been brought out by General Electric Co. These single-unit starters, also suitable for primary control of wound-rotor motors, consist of two mechanically interlocked reversing contactors, a two-pole overload relay, and either a circuit breaker or a fusible or nonfusible motor-circuit switch. Designed to provide full-voltage reversing control and short-circuit protection in one unit, and greater protection for equipment and operators, the starters are completely wired and ready to operate. The starters are available in sizes 0 to 4, covering single-phase and 3-phase motors in sizes up to and including 100 horsepower at 440 or 550 volts. Fusible forms combine a manually-operated motor circuit switch with clips for cartridge-type fuses. Under short-circuit conditions, fuses provide fast interruption, having maximum available current of



(*Continued on Page* 124)

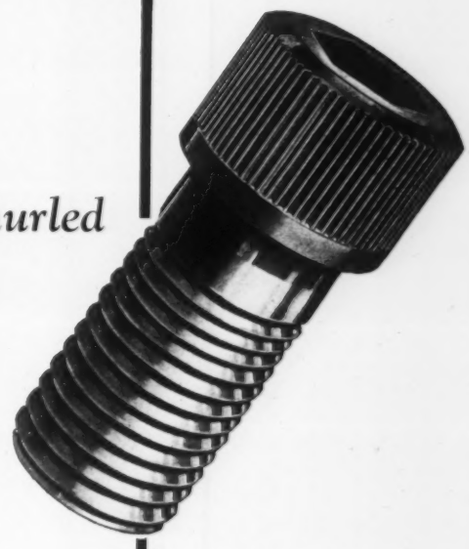
Where the design calls for

CAP SCREWS

Specify UNBRAKO* *Knurled*

SOCKET HEAD CAP SCREWS

The knurled heads not only dress up any product on which they are used but also help speed up its assembly. The "Unbrako" knurls gear right to the mechanic's fingers . . . prevent annoying time-wasting finger slip so the screws can be turned in faster and farther before he must reach for a wrench. Also, this knurling permits an ingenious method of locking after countersinking. It's explained in the "Unbrako" Catalog. Get a copy today.



SET SCREWS THAT MUST "STAY-PUT"

Specify UNBRAKO* *Self-Locking*

HOLLOW SET SCREWS

with Knurled Points

When these screws are tightened up as usual, the knurled points lock automatically. They stay put regardless of vibration or jarring . . . yet can be easily removed and used again and again. Don't fail to investigate "Unbrako" Self-Lockers . . . their use is an insurance against one possible cause of breakdown of the equipment you design.

Knurling of Socket Screws originated with "Unbrako" years ago.

For complete information send for the "Unbrako" Catalog.

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA. BOX 102

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*Reg. U. S. Pat. Office

3 BIG SAVINGS WITH ROPER Rotary PUMPS

1 — SAVE 50% TIME

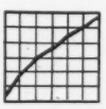
Saving installation time is most important in plants producing for Victory — one customer writes: "So far the new ROPER has proved the easiest of all to install. In fact the last 6 ROPERS installed saved 18 hours labor — about 3 hours on each."

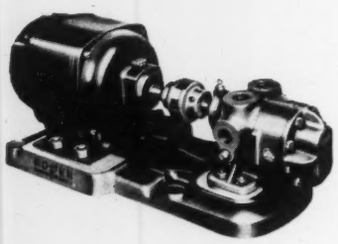
2 — SAVE 52% SPACE

Today with increased production so vital plants welcome opportunities to get efficient equipment that saves space. Roper "direct drive" pumps require only 48% as much floor space as other models.

3 — SAVE 20% POWER

Here is another saving important to the Victory program — Roper "hydraulically balanced" Pumps reduce power consumption as much as 20%.





OTHER FEATURES

TIME, space and power savings are most important but remember other outstanding Roper features too! Ropers are "always primed" ready for action; long on suction lift; quieter in operation; simplest in design — only two moving parts; automatically lubricated; leakproof; and absolutely dependable on long hard jobs.

THOUSANDS IN USE

Roper Rotaries are being used by thousands of defense plants throughout the U. S. Their dependability and the savings they make possible are vital to all who must handle liquids. Manufacturing and processing industries must have trouble-free equipment — that's why "ROPER" is specified on so many purchase orders.

PUMPING ANY LIQUID

Whether for lubricating systems, general transfer work or for use on intricate hydraulic systems, there is a Roper to do the job. Roper Pumps can be standard fitted, bronze fitted or all bronze—capacities from 1 to 1000 gallons per minute—pressures up to 1000 lbs.—speeds to 1800 revolutions per minute — mountings and drives for every practical need.

HYDRAULICALLY BALANCED

THIS SEAL appears on every ROPER "hydraulically balanced" PUMP. It means higher efficiency, quieter operation, greater dependability and longer life.

Get this valuable Book of Pumping Information

Send for your free copy of catalog. Learn how you can save time, money and trouble.

ask for Catalog No. 932

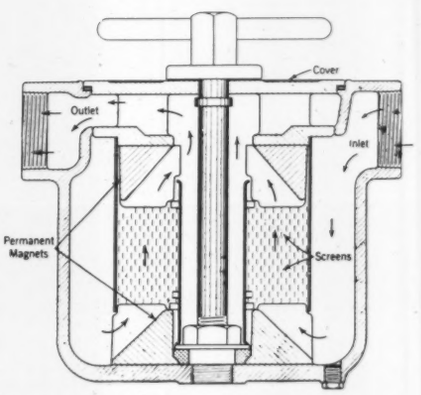
GEO. D. ROPER CORP., ROCKFORD, ILL.

(*Continued from Page* 118)

10,000 amperes at rated voltage. Circuit breaker forms provide simultaneous tripping of all phases on short circuits, and have a trip-free mechanism preventing holding the breaker closed under short-circuit conditions. After operation the breaker can be reset by returning handle to the off position. In the smaller ratings breakers have bimetal thermal trip units only and the larger breaker ratings have interchangeable bimetal thermal trips, as well as magnetic instantaneous trips. Undervoltage protection is provided by an electrical interlock on each contactor when starters are used with a momentary contact pushbutton station.

Permanent Magnet Filter

HAVING a greater capacity than any previous filter manufactured by S. G. Frantz Co. Inc., 161 Grand street, New York, the company's permanent magnet filter designated as PQ-6 is especially adapted to remove harmful iron and steel



particles from circulating coolant systems of machines used in tapping, grinding, deep hole drilling, reaming and rifling, etc. It will also remove foreign material from circulating lubricating oil systems of pumps, diesel and blooming mill engines, rod mills, roll grinders, etc. The capacity of the filter is 200 gallons per minute; pipe size connection is 3 inches, and height 15⅝ inches.

Circuit Breaker for Aircraft

FOR protecting airplane lighting, motor, radio and control circuits, Heinemann Circuit Breaker Co., 113 Plum street, Trenton, N. J., has developed a small circuit breaker to meet specifications of aircraft manufacturers. While retaining all mechanical features of a larger unit, this breaker has been reduced in size and weight by approximately 50 per cent, measuring 2¾ inches in length, 3 21/32 inches in height and .865 inch in width, and weighing 4½ ounces. Maximum capacity is 50 amperes, operating on circuits up to 28 volts direct current, while interrupting capacity is 3500 amperes. Fully electro-

Brad Foote Gears

☆

Brad Foote Gears have a great responsibility these days in the Victory program.

Into each gear goes a full measure of the ability, performance and capacity, that has made this plant one of the most important units of its kind.

☆

BRAD FOOTE GEAR WORKS

1301-G S. CICERO AVENUE • • • CICERO, ILLINOIS

FOR BETTER MACHINES AND APPLIANCES

"All three, gentlemen, Strength, Structure and Porosity—plus lighter weight and thousands, yes thousands, of trouble-proof operating hours without additional lubrication."

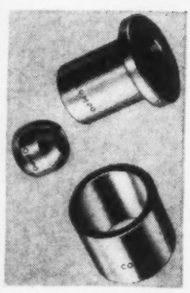
The Pioneer—
that's "First" This Year!

Reg. U.S. Pat. Off.

Compo

The outstanding achievement of the art of Powder Metallurgy —the bearing that is the choice of leading designing engineers.

Made of pure metal powders die pressed to shape, alloyed at high temperatures, finished to accurate dimensions and impregnated with lubricant—an oily surface to start on—an oily film to run on—lubrication, when and as needed—no oil holes, grooves, ring oilers or other costly lubricating devices.



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POROUS BRONZE
BEARINGS

IMMEDIATE SHIPMENTS—hundreds of sizes in Stock
Diversification of sizes and shapes--thousands of tools on hand
Engineered Sales • Continuous Research • Skilled Production
Write for Bulletin, Stock List or Die List—No Obligation

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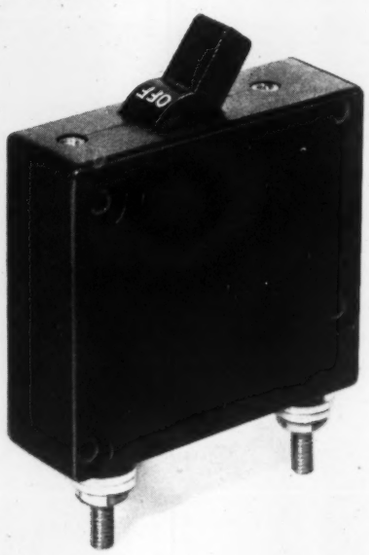
Bound Brook Oil-Less Bearing Co.
(Established 1883)
Main Office and Plant, Bound Brook, N. J.
Detroit, Michigan, 1255 Book Building
Los Angeles, Cal., 1901 Santa Fe Avenue

FOR BETTER MACHINES AND APPLIANCES

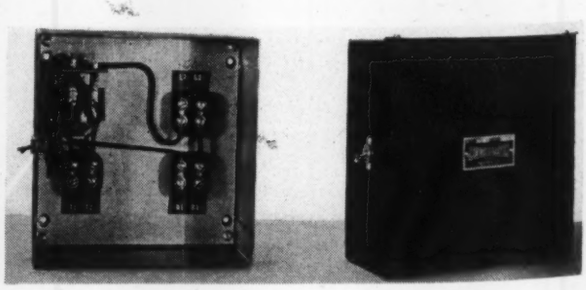
magnetic, the breaker has a definite instantaneous trip point entirely independent of its time-delay characteristics. Magnetic trip with time-delay gives delayed trip on harmless overloads, such as passage of inrush current, but provides a high-speed trip on short circuits and dangerous overloads. After breaker opens it may be reclosed, pro-



viding current has returned to normal, and cannot be held open against any existing overload or short circuit. Sudden and extreme changes in temperature do not affect the breaker due to the absence of any heating elements. Vibration-proof and resistant to shock, assuring constant protection under all flight conditions, the breaker is furnished with all parts cadmium-plated to prevent corrosion. Handle is of toggle-type and is available with a luminous dot in end and lettering of "on" and "off" for high visibility.

Switch Signals Alarm

FOR use on machines where it is desired to signal an alarm when a failure occurs an alarm switch has been introduced by Control-O-Matic Corp., 60 East Forty-second street, New York. There are also other applications in conjunction with pressure, float, speed, limit motion, etc., controls. Switch can be used on various line and bell voltage and requires only a bell or other signal device and wiring to make the circuit complete. In



Hundreds of tons of copper can be saved—

—BY USING **COPPER-COVERED STEEL**
(COPPERWELD)

IN PLACE OF COPPER, BRONZE OR BRASS

"Copperweld" is steel wire or rod, copper covered. The copper exterior is permanently welded (cast) to the steel core. "Copperweld" resists rust and corrosion like copper, provides adequate electrical conductivity for many electrical uses and rust-resisting high strength for many mechanical uses.

"Copperweld" can be used wherever rust-resisting strength or electrical conductivity is needed. "Copperweld" will do many jobs for which copper, bronze or brass have been used—and will do them with *much less copper*.

COPPERWELD STEEL COMPANY, GLASSPORT, PA.

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NEW YORK	*117 Liberty Street*
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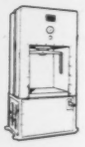
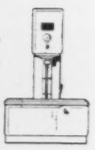
"Copperweld" has been used for 27 years by the nation's leading Power Companies, Railroads and Telephone Companies.

DLKC2 HydrOILic KNEE-TYPE PRESS OFFERS RAPID TOOL-CHANGING - - - HANDLES WIDE RANGE OF PRESSING OPERATIONS

The ease with which you can retool this DLKC2 HydrOILic press for one job after another is just the *first* thing you'll like about it. Its smooth, flexible *oil hydraulic* power, speed and control give you a new "whip" on production efficiency. The modern cut of its space-saving, projection-free, rounded frame clears the way for fast, accurate, safe operation. And the DLKC2 takes to production-line pressing jobs equally well. This versatile press is built in 5 and 15 ton capacities, with manual or electric control (or both). Maximum stroke is 18 inches; maximum daylight opening, 46 inches. Write for full details.


DLOS2-50

DLOS2-100


DLSC2

DLAC2

Write today for complete new DATA BOOK on 5-to-100-ton HydrOILic Presses. The Denison Engineering Company, 1156 Dublin Road, Columbus, Ohio.

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POWER-SPEED-CONTROL
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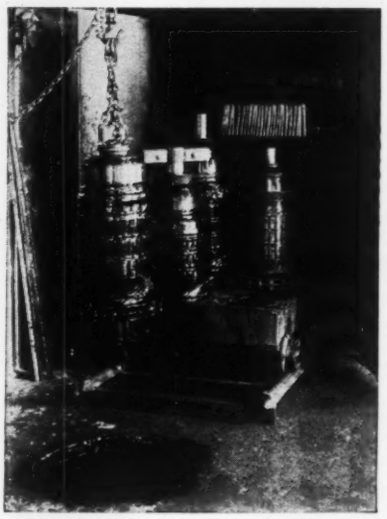
DENISON EQUIPMENT for APPLIED HydrOILics

connection with speed actuated controls, it may be used to give warning of either excessive high or low speed. For use with low-voltage alternating or direct current bells, the switch has a steel partition to separate high and low-voltage terminal blocks in cabinet. For low voltage alternating-current bells, it is equipped with a transformer, having a primary suitable for use on 110 or 220 volts, 60 cycles and a secondary of 6, 12 or 24 volts for the bell operating source. Other types can also be supplied for installations where more than one alarm switch is used employing a single bell to signal shutdown of any motor in a group, and also providing a separate enclosed set of pilot lights to indicate which motor of the group is shut down.

Finish for High Temperatures

RECENTLY developed by The Sterling Varnish Co., 146 Ohio River boulevard, Haysville, Pa., a new insulating varnish, designated as S-110, can be applied to electrical apparatus that operates at



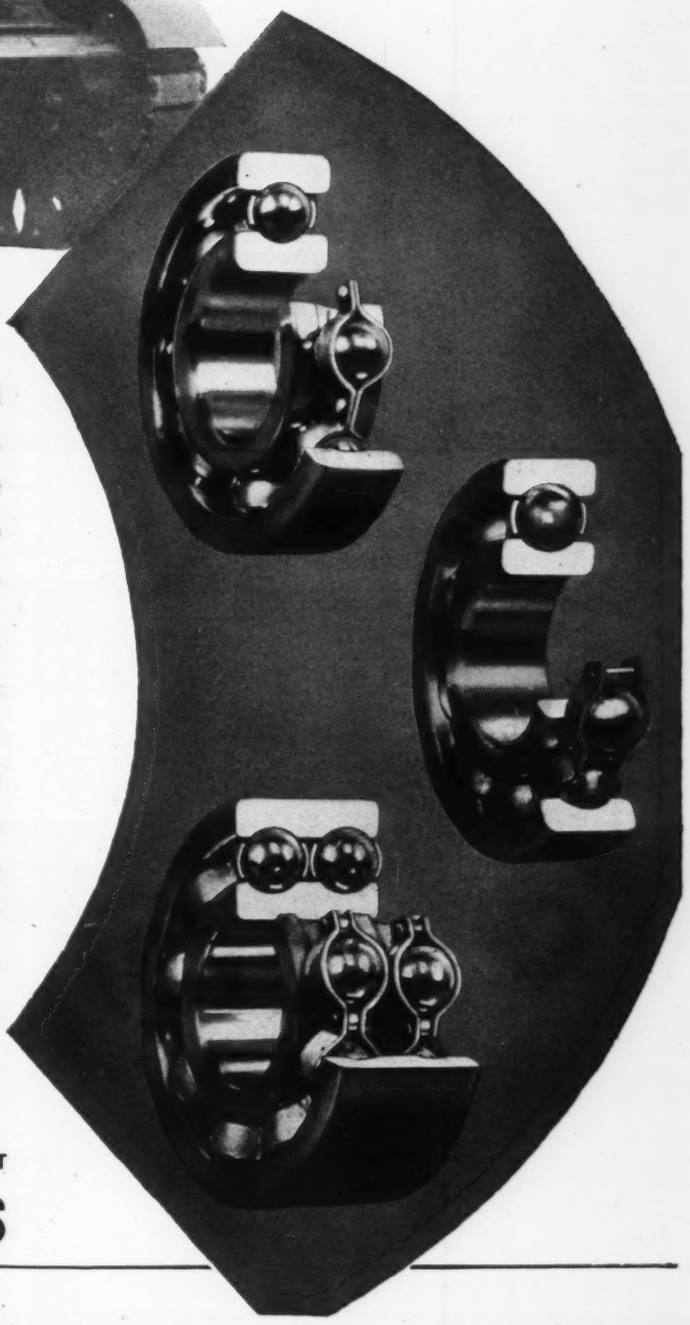
abnormally high temperatures. Tests have indicated that the finish will stand operating temperatures at 250 degrees Cent. or higher. When baked at 175-200 degrees Cent., it dries completely and does not resoften at high temperatures.

Blackening for Copper Alloys

LOW temperature blackening of copper and almost all of its alloys, including bronze and brass, has been solved by The Enthone Co., 442 Elm street, New Haven, Conn., in the introduction of its new process known as Ebonol "C". The process involves immersion in a blackening salt solution operated near the boiling point or from 200 to 212 degrees Fahr., and blackening is accomplished in 2 to 10 minutes, depending upon the alloy. Suitable for blackening copper, beryllium copper, bronze, phosphor bronze, and brasses with zinc content of 35 per cent or less, the process produces a coating

Prepared and Determined

to Help America ROLL Ahead



MACHINES and vehicles of war depend on ball bearings for efficient operation. Providing "smooth rolling" for the armed forces and for industries vital to victory is now the all-out job at BCA.

BCA is proud to share in the achievement that has made the ball bearings industry a bright spot in wartime manufacture. BCA is prepared . . . BCA is determined . . . to help the nation push uphill to the necessary record breaking production peak. BEARINGS COMPANY OF AMERICA, LANCASTER, PENNSYLVANIA

Standardize on Standard Sizes

BCA

RADIAL • ANGULAR CONTACT • THRUST

BALL BEARINGS

★ ★

QUANTITY AND QUALITY

Sure you want tracing cloth in a hurry – and lots of it! But – thanks to Arkwright – there's no need to sacrifice quality.

Years of testing in Arkwright laboratories . . . years of insistence on highest quality materials and highest standards of manufacture have made Arkwright ready for the present emergency. Today, you can order Arkwright Tracing Cloths with the same assurance of quality – and the same rapid delivery – that has made Arkwright the recognized leader in the tracing cloth field in America for over twenty years. Arkwright Finishing Co., Providence, R. I.

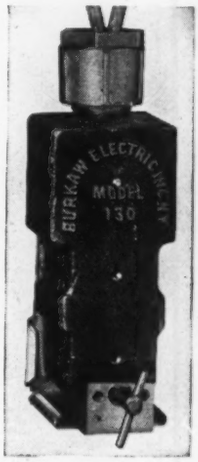
Arkwright

★ TRACING CLOTHS ★

which is essentially cupric oxide and, being integral with the base metal, cannot chip or flake. The coating is hard enough to be buffed and does not have to be lacquered to prevent wear. This finish can be used in the production of war equipment such as optical units, airplane instruments, detectors, etc. Parts that must withstand close dimensional tolerances can also be coated with this finish. The finish can be exposed to temperatures as high as 700 degrees Fahr. without harm.

Switch for Blackout Control

FOR blackout control, Burkaw Electric Inc., 381 Fourth avenue, New York, has brought out its new door-operated switch. The purpose of the switch is to prevent direct or reflected white light to the weather when doors are opened. These new door switches, both watertight and non-watertight, single and two-pole, have as their main feature a key-operated mechanical locking device which locks the switch in the closed position. This eliminates the short-circuiting switch previously installed in each circuit. The unit is cast brass, 3⅞ x 1¾ x 1¾ inches. These switches have been installed on recently completed merchant ships as well as Naval units.



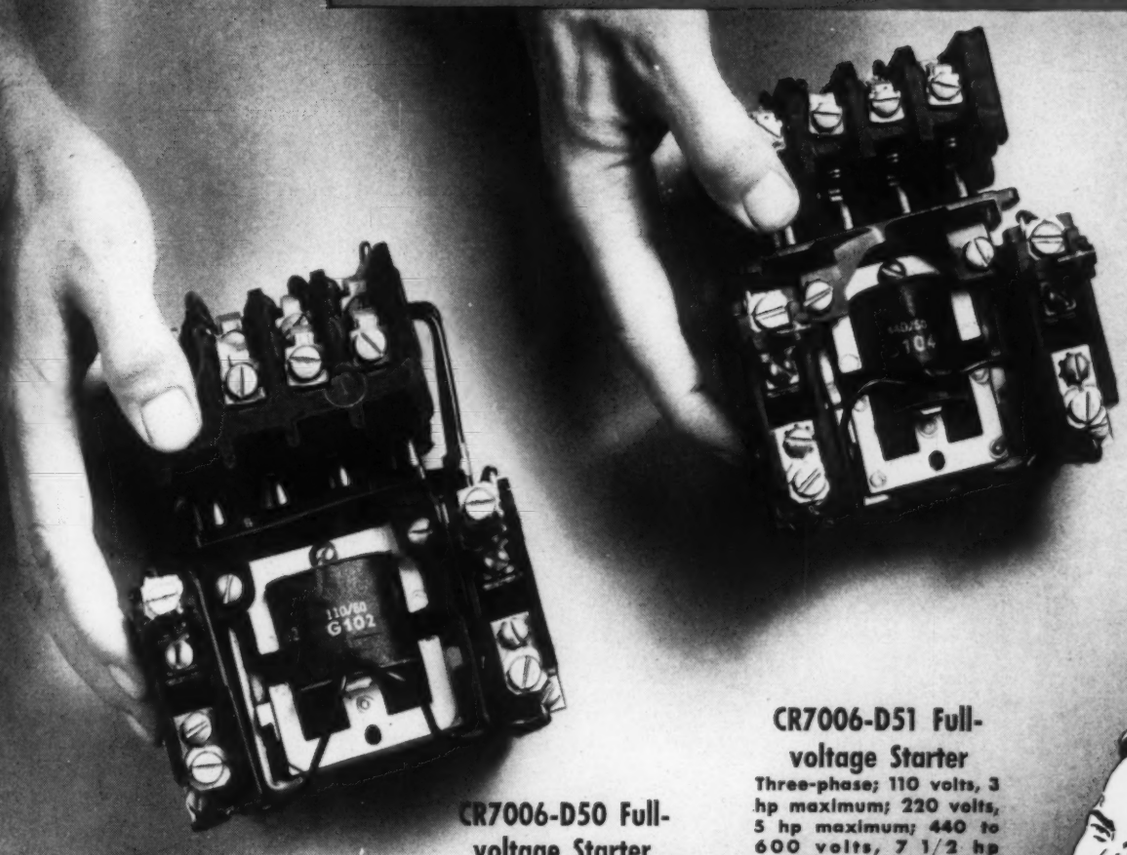
Nameplate Substitute

AS A substitute for metals for nameplates, metal tags, identification, patent number and instruction tags, Avery Adhesives, 451 East Third street, Los Angeles, has introduced its product which will adhere permanently to any smooth surface including metals, glass, plastics, enamel, varnish, and wood, and is applied without moistening. This material will adhere even when exposed to high temperatures or changing climatic conditions. It eliminates the necessity of drilling, tapping and riveting in application, yet is permanent.

Interior Fast-Drying Paint

VULCANIZER interior fast-drying paint is the new development of Belke Mfg. Co., 947 North Cicero avenue, Chicago. The paint resists corrosion as well as minimizes sulphurous fumes and acid action. It is not affected by oil, gasoline or high steam pressure, and does not peel or crack. Furnished in black only, the paint can also be used to cover pipes, fittings and other equipment subject to extreme corrosion of steam and chemical action. It will stand a temperature of about 800 degrees.

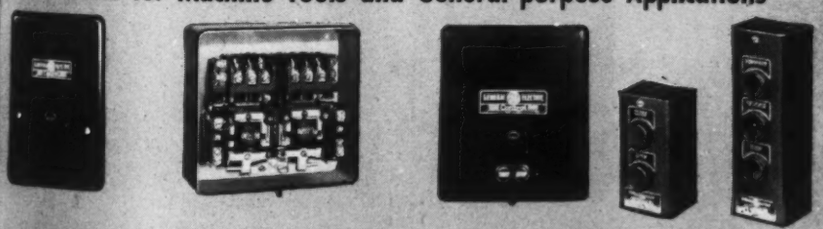
THESE MAGNETIC STARTERS ARE AVAILABLE FOR *PROMPT DELIVERY* FOR WAR WORK



CR7006-D50 Full-voltage Starter
Three-phase; 110 volts, 1 1/2 hp maximum; 220 to 600 volts, 2 hp maximum

CR7006-D51 Full-voltage Starter
Three-phase; 110 volts, 3 hp maximum; 220 volts, 5 hp maximum; 440 to 600 volts, 7 1/2 hp maximum

Starters for Machine Tools and General-purpose Applications



Enclosed CR7006-D50 Starter
Three phase; 110 volts, 1½ hp maximum; 220 to 600 volts, 2 hp maximum.

CR7009-B31JD Magnetic Reversing Starter
Three-phase; 110 volts, 3 hp maximum; 220 volts, 5 hp maximum; 440 to 600 volts, 7½ hp maximum.

Enclosed CR7006-D51 Starter with Push-button in Case
Three-phase; 110 volts, 3 hp maximum; 220 volts, 5 hp maximum; 440 to 600 volts, 7½ hp maximum.

CR2943 Push-button Stations
These accessory stations are available for either START-STOP or FORWARD-REVERSE-STOP service.

JUST pick up your phone and call the nearest G-E office. Tell us your priority rating and the type of starter you want. In most cases, we'll be able to have your starter, or starters, on the way to you before the end of the day.

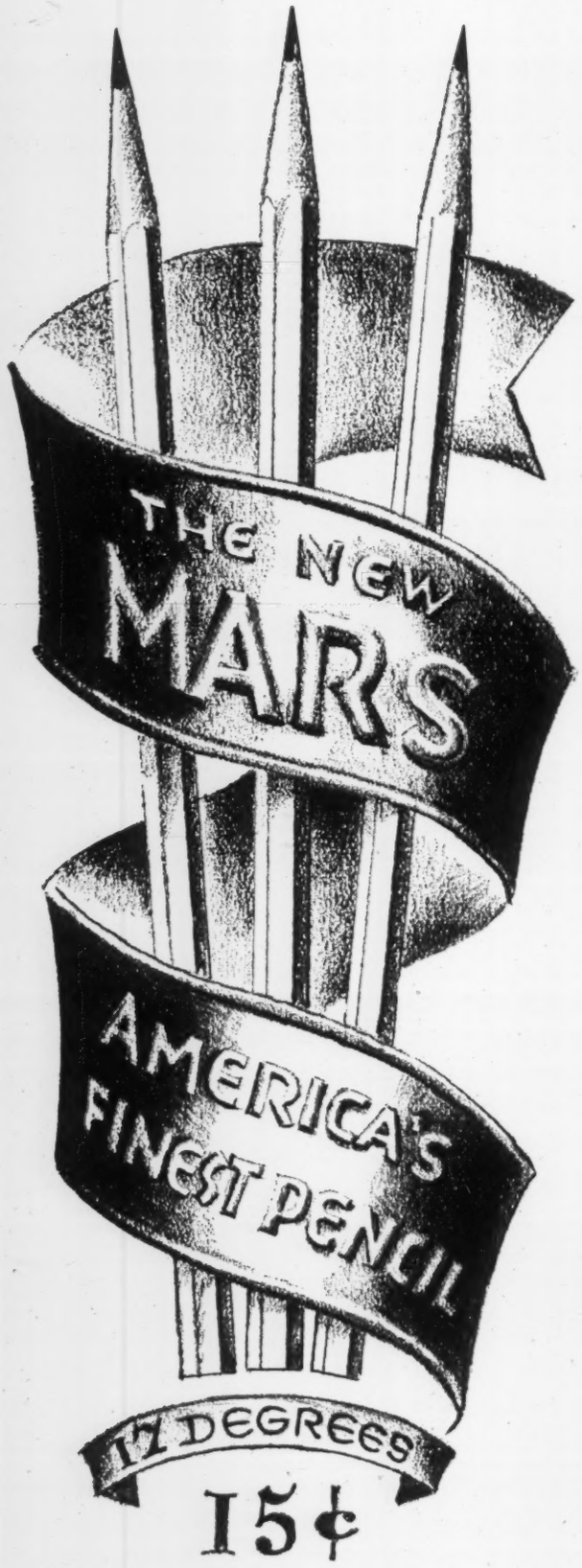
Centrally located warehouses which carry an ample stock of the popular sizes and types of magnetic starters make this kind of service possible.

When you need motor control in a hurry, call your local G-E salesman. In most cases he will have just what you need in stock. *General Electric, Schenectady, N. Y.*

GENERAL ELECTRIC

676-42-8490

General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.



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NATIONAL DISTRIBUTORS:
KEUFFEL & ESSER CO.
NEW YORK

MEN
Of Machines

ELECTION of Edwin H. Brown as vice president in charge of engineering and development of Allis-Chalmers Mfg. Co., was announced recently. His new post will correlate all engineering activities and development of new equipment. Previous to his appointment, Mr. Brown had been manager and chief engineer of the engine and condenser department for seven years. After obtaining his engineering degree from the University of Nebraska in 1906 he entered the Allis-Chalmers training course for graduate engineers, upon the completion of which he served in various capacities with the company. He then became assistant manager of the steam turbine department, and in 1935 head of the engine and condenser section.

ONE of the best known figures in the gear industry, John H. Flagg was elected president of the American Gear Manufacturers association at its recent annual meeting. Mr. Flagg was born in New York City in 1898 and spent his early life in Hackensack, N. J. Originally preparing for a career in the Navy, he was appointed to the United States Naval academy. In 1917 he was commissioned as ensign and served overseas on escort duty. Resigning

NO DRILLING NO MACHINING NO EXTRUDING

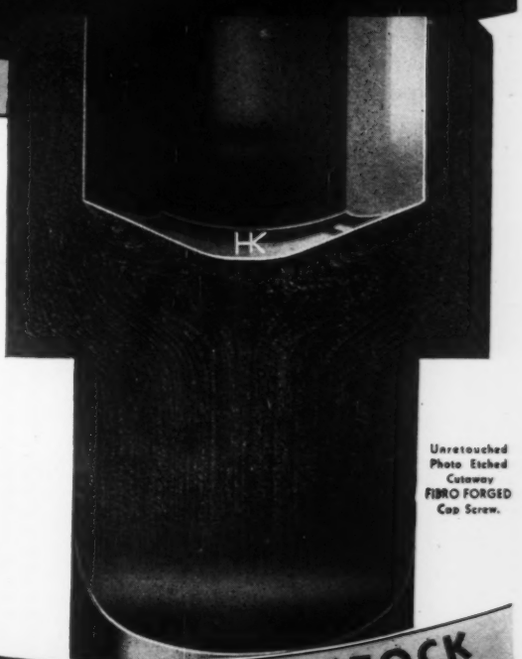
ON TIME

NOT TOO LITTLE—NOT TOO LATE

"On Time" is no hollow phrase to the Holo-Krome organization. It means War Production Demands must be met—"On Time".

All out—"On Time" service is the regular daily routine at Holo-Krome plus

GUARANTEED Unfailing PERFORMANCE



Unretouched Photo Etched Cutaway FIBRO FORGED Cap Screw.

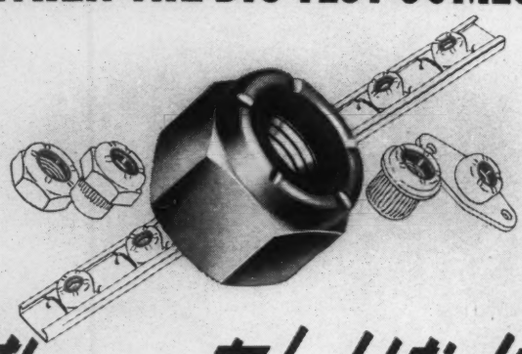
COMPLETELY COLD FORGED FROM SOLID STOCK

HOLO-KROME *fibro forged* TRADE MARK **SOCKET SCREWS**

THE HOLO-KROME SCREW CORP. HARTFORD, CONN., U. S. A.

The Boeing B-17 Flying Fortress is fastened throughout, at important structural and secondary connections, with Elastic Stop Nuts.

WHEN THE BIG TEST COMES



these nuts hold tight

Bolted connections on military airplanes call for lock nuts that hold with a grip which is positive and yet resilient . . . a grip that withstands the complex vibrations, the stresses, and the shocks, of high-speed maneuvering . . . a grip that protects the ships and the men who fly in them.

Evidence that Elastic Stop Nuts meet these all-important requirements is found in the fact that they are used for vital structural and equipment fastenings on *every* military airplane built in the Western Hemisphere.

There are more Elastic Stop Nuts on American airplanes, tanks, and other war equipment, than all other lock nuts combined.

THE RED LOCKING COLLAR . . . SYMBOL OF SECURITY

ELASTIC STOP NUT CORPORATION
2326 VAUXHALL ROAD • UNION, NEW JERSEY

Elastic Stop SELF-LOCKING NUTS AND AIRCRAFT FITTINGS

HELP AMERICA KEEP 'EM FLYING

» Catalog will be sent on request
. . . and nuts for testing are readily available.

from the Navy after the war, he entered Yale university and graduated in 1920 from the Sheffield Engineering school where he had specialized in mechanical engineering. After graduation he joined the Watson-Flagg Co. of which he is now president. He has been instrumental in the design of the company's gear motors and gear reduction units on which he holds numerous patents. Mr. Flagg assumes the leadership of the American Gear Manufacturers association at the busiest time of its history; his broad experience in gearing and organization should enable him capably to fulfill his new responsibilities.

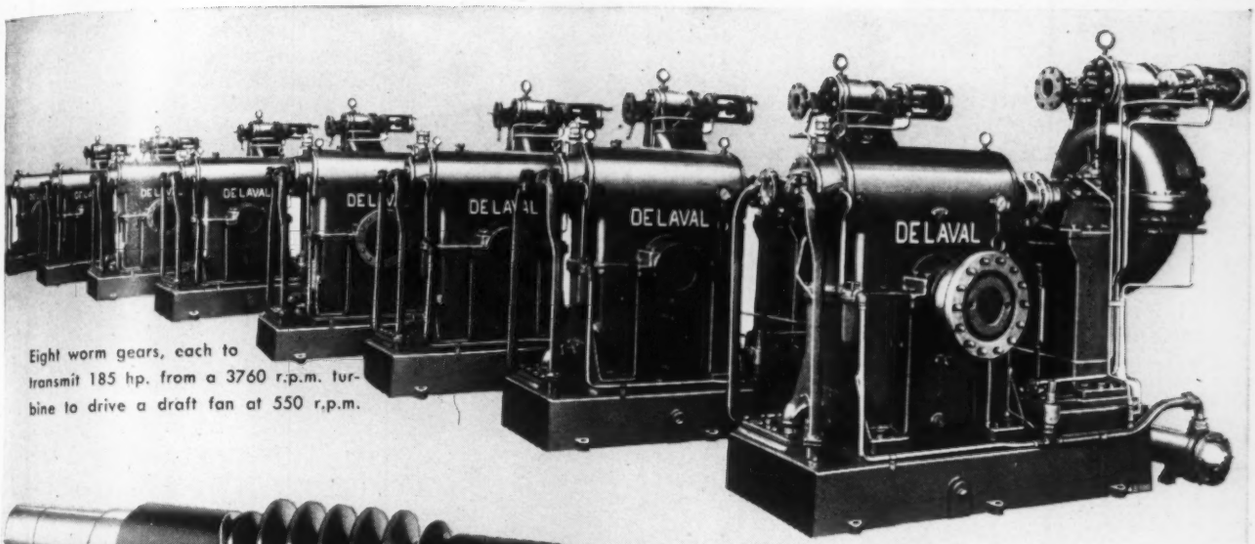
♦

JOHN S. MARSH has resigned from the staff of Alloys of Iron Research of the Engineering Foundation to accept a position with the research and development department of Bethlehem Steel Co.

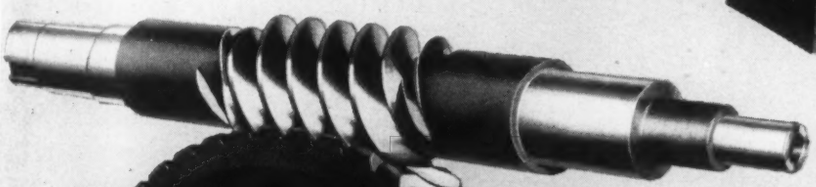
♦

HERBERT J. FRENCH, national vice president and in charge of the alloy steel and iron research at International Nickel Co. Inc., has been made senior technical consultant in charge of Metallurgical and Specifications section of the Iron and Steel branch of the War Production Board.

AFTER serving as first vice president of the American Society of Tool Engineers and also national chairman of the society's Emergency Defense Training committee, Otto W. Winter will take over the presidency of the organization, for 1942. Mr. Winter who is vice president in charge of manufacturing, Republic Drill & Tool Co., Chicago, has a background of extensive experience in both the tool engineering field and also in the activities of the national society. As head of the Emergency Defense Training committee, he has devoted a great part of his spare time in assisting, in an advisory capacity, in training of defense workers, in compiling and distributing educational material for training workers, and recently in conducting an informative survey of tool engineering facilities and material available. The committee under Mr. Winter's direction has reviewed over 500 volumes of books or material available as educational matter for training of tool engineers. His early training was that of machine and tool-maker for various tool design machine shops—this even before graduation. After graduation he became engaged in machine and tool design



Eight worm gears, each to transmit 185 hp. from a 3760 r.p.m. turbine to drive a draft fan at 550 r.p.m.

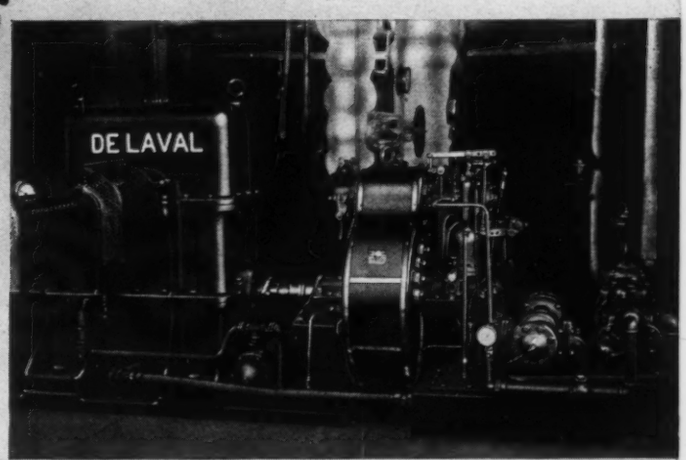


FOR SMALL TURBINE DRIVES *specify* DE LAVAL WORM GEARS

The high efficiency and reliability of De Laval worm gears is especially valuable in continuous, 24-hour service. The efficiency approaches 97 per cent at some ratios and increases, rather than recedes, with use. Power is transmitted without vibration, chatter or shock. The only maintenance required is occasional inspection of the oil level in the casing.

The driven shaft can be extended to either right or left, or both, or either up or down, or both.

Ask for Booklet W-1130 on "Industrial Applications of Worm Gears"



Worm gear transmitting 225 hp. from 3900 r.p.m. turbine to drive a paper machine. A De Laval worm gear in similar service has been in continuous operation for more than 15 years.

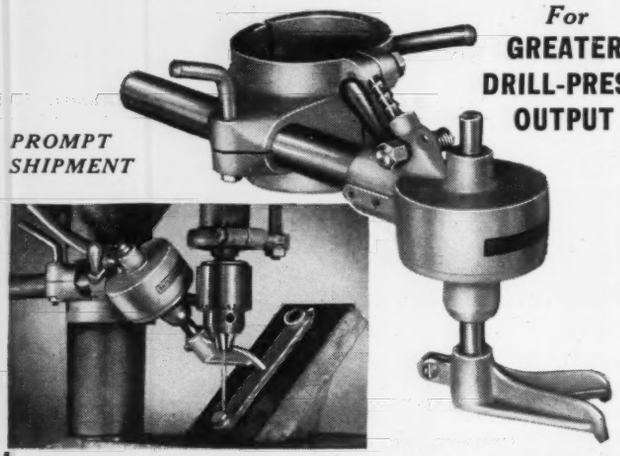
DE LAVAL WORM GEAR DIVISION
of the De Laval Steam Turbine Co., Trenton, N. J.

MANUFACTURERS OF TURBINES . . . STEAM, HYDRAULIC; PUMPS . . . CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT, MOTOR-MOUNTED, MIXED-FLOW, CLOGLESS, SELF-PRIMING; CENTRIFUGAL BLOWERS and COMPRESSORS; GEARS . . . WORM, HELICAL; and FLEXIBLE COUPLINGS

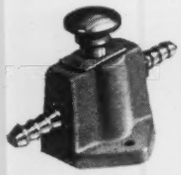
ANNOUNCING AIR-CLAMP

For GREATER DRILL-PRESS OUTPUT

PROMPT SHIPMENT



WHEREVER a drill comes down, *something* must hold the work. Wherever a drilling-jig is required, *Air-Clamp* will simplify it. Wherever *speed* is desired, *Air-Clamp* will produce it. *Air-Clamp* holds with relentless pressure; it is undisturbed by size variations (such as in castings), it scoffs at vibration (how many drills have been broken due to faulty holddowns?), chatter, snagging. *Air-Clamp* holds work of any size or shape in any position, at any angle. It can pay for itself on a single fixture; it can save its cost on a few days' drill-press output. It reduces operator fatigue. It saves hours and dollars in drafting-room, jig department, tool room and production line. *Air-Clamp* fits any drill-press having a cylindrical column. Special fixtures for Tee-slotted tables, light milling work, etc. Hand and/or foot control. Shipped on approval to responsible concerns.



FOOT AIR CONTROL READY!

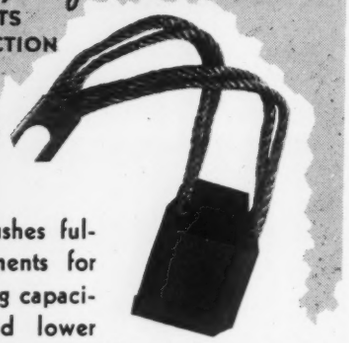
For air-operated devices. Frees hands—speeds up work! Two types: Model "ON" releases work when pedal is pressed . . . Model "OFF" holds work when pedal is pressed. Low priced. Write!

MEAD SPECIALTIES CO.
15 South Market St., Dept. 6-DA, Chicago

KEYSTONE Metal-Graphite Brushes

for efficient performance...

MOULDED-IN SHUNTS
THE PERFECT CONNECTION



● Keystone Brushes fulfill today's requirements for higher current carrying capacity, less friction and lower operating cost. They are ideal for cool operation and long life in the most severe and exacting applications from small fractional-horsepower motors to large 40,000 ampere homopolar generators.

Keystone Engineers will be glad to work with you on any of your individual brush problems. There is no obligation. Write for new catalog on the complete line of Keystone Brushes.

KEYSTONE CARBON CO., INC.
1935 STATE ST. SAINT MARYS, PENNA.

work, analysis, time study, shop layout and sales engineering work with companies such as Timken, Harrison Radiator, Cincinnati Milling Machine and Cincinnati Grinders Inc. In 1933 he was consultant on machine tool manufacture in Russia, and later became associated with Whitman & Barnes, in their cutter and special tool division. Subsequent to this he was connected with Kent Owens Machine Co. as consultant in industrial engineering work. Since 1937 he has been associated with Columbus McKinnon Chain Corp. and Chisholm-Moore Hoist of Tonawanda, N. Y. Last year he was appointed to the vice presidency of the Republic Drill & Tool Co.

♦

HAROLD H. STRAUSS has joined the Northrop Aircraft Co. Inc., Hawthorne, Calif., as senior stress analyst.

♦

JAMES E. DAVIS is now a junior aeronautical engineer, Aeronautical Materials Laboratory, Naval Aircraft Factory, Navy Yard, Philadelphia.

♦

ROGER M. DAUGHERTY has been appointed vice president and chief engineer of the defense division of the Detrola Corp. He was previously connected with the Crosley Corp., and has been active in every phase of the communications field, including engineering and designing.

♦

EDWARD RILEY has joined the staff of the Automotive Council for War Production and has been assigned to the Tank, Combat Car and Parts Division. Mr. Riley is an automotive engineer with nearly 20 years' experience in engine, body and chassis design.

♦

WILLIAM E. BOEING, retired pioneer aircraft builder and founder of the Boeing Aircraft Co., has offered his services for the duration of the war to the company he headed. He will act in an advisory capacity.

♦

MARION P. CREWS, a veteran of fourteen years' experience in aeronautical engineering, will serve as liaison man for all branches of the Boeing Airplane Co. and Boeing Aircraft Co. with the materiel division of the Air Corps, handling both business and engineering relationships. Mr. Crews is a former CAA official.

♦

CHARLES W. KYNOCH, chief engineer of the export division of Chrysler Corp., has been appointed associate director of the Motor Transport division, Engineering Branch of the Quartermaster Corps. S. P. THATCHER of U. S. Rubber Co. has become special assistant to BRIG.-GEN. J. L. FRINK, chief of the Motor Transport Division of the Quartermaster Corps where he will develop a rubber conservation program for the U. S. Army.

♦

CARL HART, Berne, Ind., has been added to the technical staff of the Magnavox Co. Inc., Fort Wayne, Ind., as design engineer. Formerly service

(*Concluded on Page* 142)

Small Motor Starting Switches

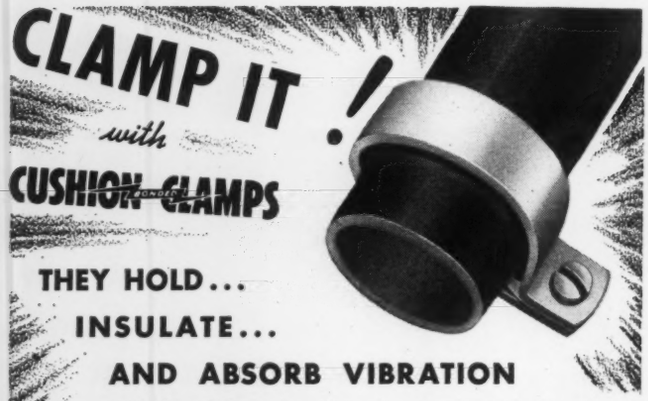
ACROSS-THE-LINE TYPE Tumbler Switches, without overload protection . . . Give positive control for motors; especially suitable for oil burners, refrigerators, motor-driven machinery and lighting loads.

These switches have rugged, durable mechanisms built to perform with the sturdy integrity characteristic of Arrow-H & H Lines. Bakelite arc snuffers increase breaking capacity; kick-off release mechanically starts the switch blades in motion and prevents sticking; extra-heavy blades and contact jaws increase current-carrying capacity.

Different styles of mounting are supplied for a wide range of machine-design requirements. Separate switch units are available for installations in switch housings built into motor-driven machinery.

No. 6808 (upper right) is a double-pole switch for single phase motors; No. 7808 (lower left) is 3-pole for 3-phase jobs. Also, the line includes 3-way, 4-pole and 2-speed reversing switches. All have horsepower ratings . . . Everything you may need in this line will be found in Motor Starting Switch Catalog No. 9-M — on request.

INDUSTRIAL CONTROL DIVISION
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.



THEY HOLD...
INSULATE...
AND ABSORB VIBRATION

Designed for and used by the thousands in the aircraft industry, these *modern* clamps are finding many other made-to-order applications wherever tubing, pipe, conduit or wire must be held.

These are the only clamps with a resilient Neoprene cushion thermo-welded to the clamp itself. They provide a permanently tight support—they cushion vibration—and are quickly installed.

Many styles and sizes of Bendix Cushion-Clamps, in aluminum and stainless steel, are immediately available. Special styles can be supplied promptly. Complete data and engineering are at your disposal. Write or wire your requirements.

Thousands used on Airplanes—thousands of other uses

BENDIX North Hollywood
SUBSIDIARY OF BENDIX AVIATION CORPORATION

BECAUSE NOTHING TAKES THE SHOCK LIKE RUBBER

GUARDIAN DIRECT DRIVE COUPLINGS

PROLONG LIFE—
ADD TO EFFICIENCY

Exclusive rubber cushion made with oil-resisting treatment and gripped permanently by die-cast ends combines positive drive with resilient protection against misalignment and free end float. No parts to get out of order, become noisy, need replacement or lubrication. No backlash.

Custom made in various degrees of flexibility engineered to job. Lengths from 2 1/2" up. Bores 5/16-inch, 3/8-inch, 7/16-inch, and 1/2-inch. More than 750,000 in service.

Write or wire today for testing sample and complete information.

GUARDIAN FLEXIBLE COUPLINGS
212 E. MICHIGAN ST. MICHIGAN CITY, IND.

(*Concluded from Page* 136)

manager, RAY YERANKO has been promoted to the engineering staff.

♦

MILTON C. EVERETT has become connected with the engineering department of Ranger Aircraft Co.

♦

S. N. F. HEDMAN, associated with the General Electric Co. about 17 years, has been appointed design engineer, mechanical drive section, Turbine Engineering department of the company.

♦

FRENCH E. DENNISON, who has been in charge of the small commercial refrigeration development department of York Ice Machinery Corp., York, Pa., has been called by the War Department to serve as chief inspector for the Philadelphia Ordnance district.

♦

DR. R. G. SPENCER has been named chairman of metallurgical research to take care of expanded industrial research projects recently undertaken by the Armour Research Foundation, Illinois Institute of Technology, Chicago. Dr. Spencer is research physicist at the Armour foundation.

♦

M. L. CARSON has taken over the management of the engine and condenser department of Allis-Chalmers Mfg. Co., replacing EDWIN H. BROWN who recently was appointed vice president in charge of engineering and development.

♦

JOHN MCBROOM has recently joined the engineering staff of the Hydro-Arc Furnace Corp., Chicago. After graduating with a mechanical engineering degree from the University of Minnesota, he became connected with the Duraloy Co., and subsequently, the Pittsburgh Lectromelt Furnace Corp.

♦

R. S. ELBERTY JR. has joined the T. W. & C. B. Sheridan Co., in its offices at 135 Lafayette street, New York, as experimental engineer.

♦

DEAN CULLEN SMITH has been made head of a research staff of Curtiss-Wright Corp.'s Buffalo plant to develop new ideas in post war air travel and explore possibilities for air freight expansion.

♦

WILLIAM D. KEEFE of the Fedders Mfg. Co. Inc., Buffalo, has been appointed a member of the advisory committee of the air conditioning and commercial refrigeration industry of the War Production Board.

♦

DR. C. F. RASSWEILER, director of research at Johns-Manville, has been named vice president of the corporation. He will continue in charge of the company's research and development activities.

♦

J. D. WOOD has resigned as president of the Roller-Smith Co. in order to devote his entire time to his duties as chief engineer. REG HALLADAY succeeds Mr. Wood.

ROLLWAY'S RIGHT-ANGLED LOADING

Keeps Bearings Rolling 168 Hours a Week

ABOVE — TYPE MCS
Double Width Radial With Separable Outer Race.

RIGHT — TYPE DAT
Thrust Bearing Double Acting, Aligning.

NO
Compound Loads,
NO Complicated Stresses.
They Give Maximum Capacity in Minimum Space.

Simple, right-angled loads carried on rollers of uniform cross-section . . . with no compound loads, no oblique loads to complicate the stresses . . . that's why Rollway's Solid Cylindrical Roller Bearings are tailor-made for the war-time 168-hour week.

All loads are uniformly distributed. All races are parallel to the roller axis. There's no pinching effect, no wedging of the rollers against the radius of the race. Sliding friction and wear-back of roller ends are held to a minimum.

Splitting the load into components of pure thrust and pure radial makes for compactness, hence you can change your present bearings to Rollway's of higher capacity rating in the same dimensional limits.

In no other type of thrust bearing can so much capacity be obtained in so compact a form. Short, accurately dimensioned rollers insure free rolling and low torque, regardless of the oil-film. And staggered position of the thrust rollers equalizes the distribution of wear.

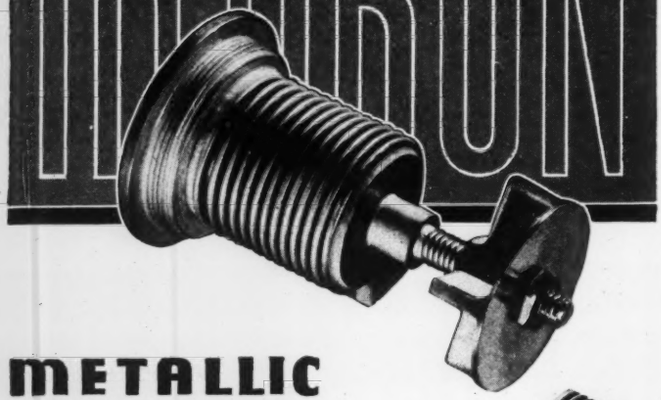
STANDARD SIZES FOR MOST APPLICATIONS

Rollway's unusually wide range of series and types provides standard metric dimensions and tolerances for practically every design, providing both replacements and change-overs at lower cost. Send us your drawings—particularly your conversions—for free engineering analysis and bearing recommendations, a free service that's worth real money to you.

ROLLWAY BEARING COMPANY, INC., SYRACUSE, N. Y.

BUILDING HEAVY-DUTY BEARINGS SINCE 1908 **BEARINGS**

HYDRON



METALLIC BELLOWS

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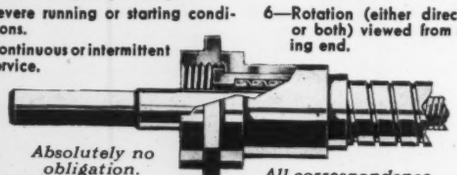
3—Severe running or starting conditions.
4—Continuous or intermittent service.
5—Unusual external operating conditions.
6—Rotation (either direction, or both) viewed from driving end.



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All correspondence confidential.

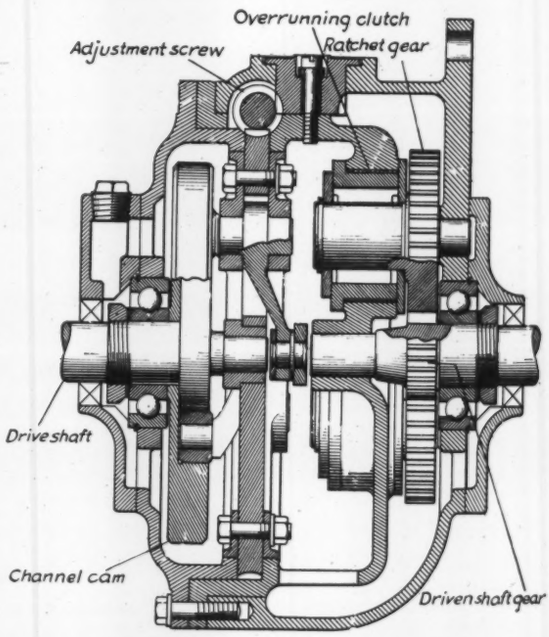
STOW MANUFACTURING CO., Inc.
11 Shear St. Binghamton, N. Y.

Noteworthy PATENTS

Variable Speed Drive Is Positive

DEVELOPMENT of a positive-drive, mechanical, infinitely variable speed transmission has long been a challenge to engineers and designers. One of the chief disadvantages of such mechanisms has been that constant angular velocity of the driven shaft is obtainable only in a comparatively small part of the total range of available speed. Whereas this criticism is to some extent applicable to the present invention, the variations in angular velocity are practically negligible.

Assigned to the Morse Chain Co., this patent makes provision for three overrunning clutches



Infinitely variable speed and substantially constant angular rotation of the driven shaft is provided by positive transmission

used as ratchets and actuated by means of a suitable linkage from a cam track formed in a channel cam and driven by the driveshaft. The cam track is so designed as to oscillate the bell-crank at a constant angular velocity. Also, the proportion and angular relationship of the various components of the linkage system are so adjusted as to transmit oscillation to the ratchet arm at a substantially uniform velocity. In accomplishing this, the effective lengths of the intermediate link,

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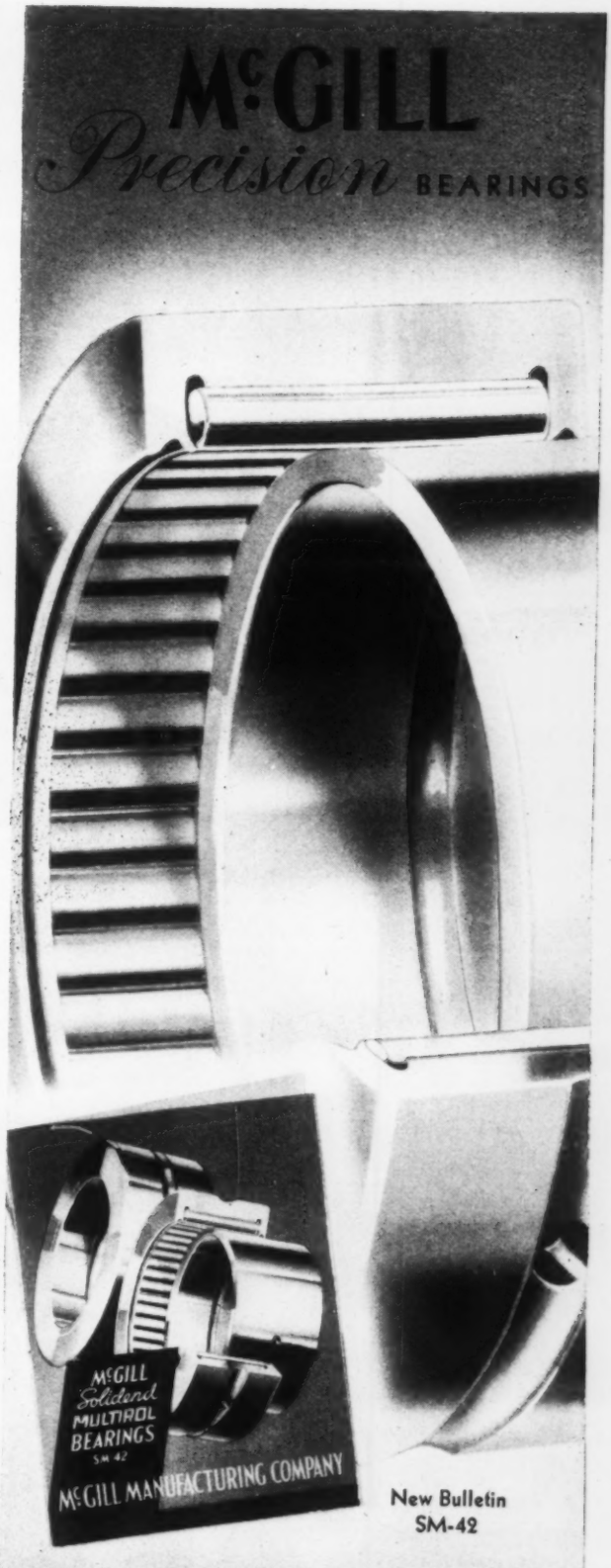

New Bulletin SM-42

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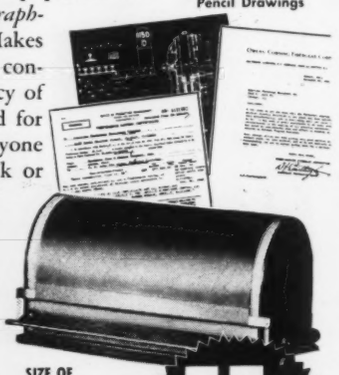

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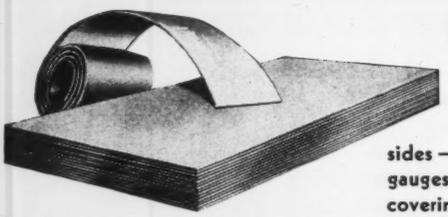
ELEPHANT BRAND PHOSPHOR BRONZE

WIRE · SHEETS



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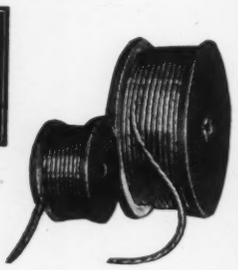

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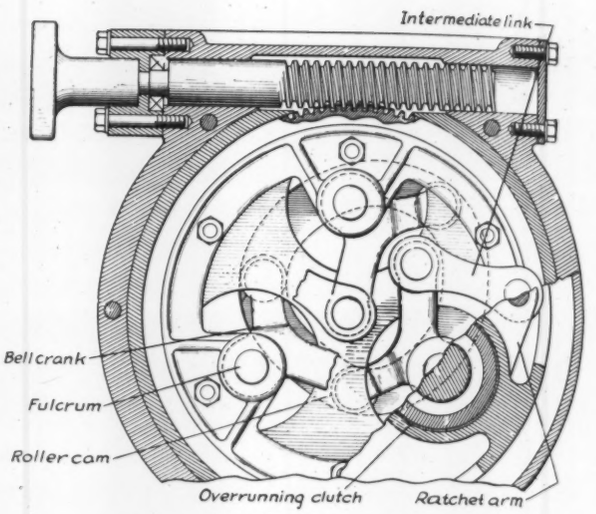

Rotation of adjusting handwheel causes a change in stroke of ratchet arm, effecting speed change

the longer lever of the bellcrank, and the ratchet arm are practically identical.

Speed adjustment is obtained by rotation of the handwheel shown in the upper part of the illustration. Making this adjustment causes the bellcrank fulcrum to be moved relative to the axis of the overrunning clutch, causing a change in the stroke and velocity of the ratchet arm. When this adjustment is carried to its extreme the fulcrum is moved so that it is in register with the pin on the intermediate link which also carries the ratchet arm. In this position the bellcrank will continue to be oscillated by the cam but the intermediate link will then oscillate only about the ratchet arm pin and will impart no motion to the ratchet arm.

Multiple Disks Improve Braking

APPLICATION of braking force through the medium of cast-iron brake shoes directly to the flanged wheels of railroad cars has the apparent disadvantage of increasing wear both by reason of the abrasive action involved, and because the heat generated tends to reduce the wheel tire hardness. These disadvantages have been overcome in a patent assigned to the Budd Wheel Co. by use of separate brake disks integral with the wheel axle.

Mounted rigidly on the axle is a splined drum not shown in the illustration. Floating on this drum and meshing with the spline is a brake disk. This disk is therefore capable of rectilinear motion in a direction parallel to the truck axle. The floating disk has friction surfaces on both sides, and a second disk which does not float on the splined drum but is fastened integrally to the car wheel has a friction surface on the inside only.

Two brake shoes for each wheel are supported by a simple link from the truck frame. One of these shoes is supported freely between the two brake disks. The other bears on one side of the

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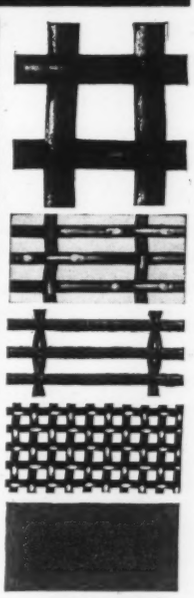

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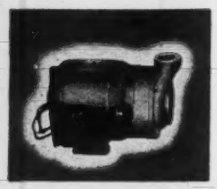

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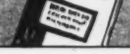
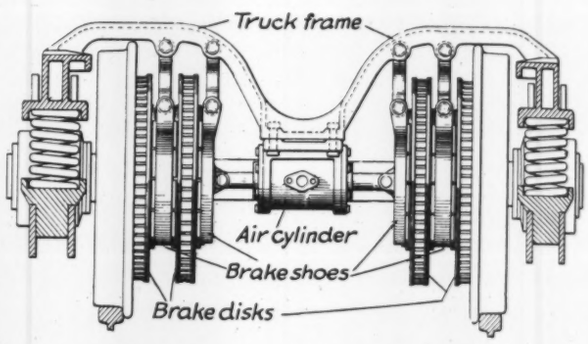


floating disk and is attached at substantially its midsection to the piston rod of a pneumatic cylinder. The cylinder itself is attached to the truck frame midway between the wheels. It contains two pistons the rods of which extend through the heads in opposite directions. Between the piston rod and the brake shoe is a pinned joint enabling the brake shoe to seat flush against the disk.

In applying the brakes, air is introduced into the center of the pneumatic cylinder between its included pistons. The pistons then move out-



Two pistons working in opposite directions in a single pneumatic cylinder equalize braking force on railroad car wheels

ward, applying a braking force to the disks. Use of a single air cylinder to operate the brakes on both wheels obviates the possibility of applying excessive braking force on one wheel and not on the other.

Brake disks are provided with a series of spiral webs which serve the double purpose of reinforcement for strength and acting as centrifugal pump impellers for inducing a stream of air across the inside of the frictional surface of the disks. Since these disks rotate with the car wheels, the cooling action is carried on whenever the car is in motion, and regardless of whether or not the brakes are being applied.

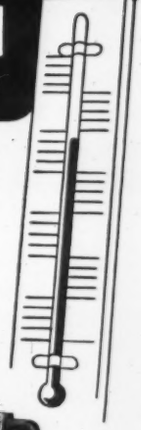
Holds Surface Speed Constant

IN MACHINE tools for profiling operations or, for that matter, any machine for processing the surface of irregularly shaped pieces, it is often necessary that the peripheral or surface speed of the piece being processed be maintained substantially constant. A simple and interesting mechanism for accomplishing this end is disclosed in a patent assigned to Doran Brothers, Inc.

Part of the mechanism consists of an irregularly shaped chain sprocket which conforms to the shape of the piece to be processed. As illustrated, this sprocket is roughly rectangular in shape with rounded ends corresponding to a radius swung from the center of rotation of the sprocket.

Drive for the mechanism originates in an electric motor enclosed in the base of the machine. This motor drives, through a suitable gear-reducer unit, a sprocket carrying a roller chain which engages,

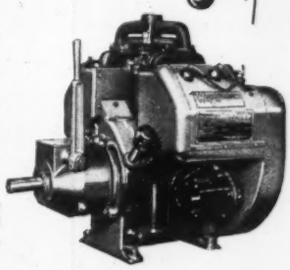
Building Hot Weather Service into WISCONSIN AIR-COOLED ENGINES



● By moving a constant flow of 500 cubic feet of air per minute, at a velocity of 1000 ft. per min., at a normal engine speed of 1800 rpm. . . .

And by *proportioning* this large volume flow of air to suit the cooling requirements of the various parts of the engine . . . directing the air currents where needed by means of baffle plates and airstream channels . . .

Wisconsin heavy-duty air-cooled engines give efficient, reliable service at extremely high operating temperatures. Cylinders, cylinder heads, valves and pistons get all the air they need for adequate heat dissipation.



Illustrated is the Model VE-4 V type 4 cyl. engine.

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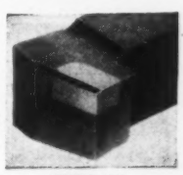

STYLE 21

STYLE 11

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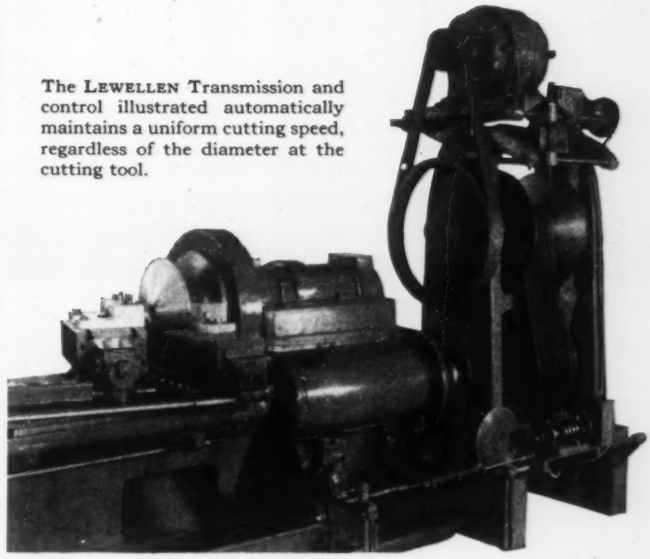
The LEWELLEN Transmission and control illustrated automatically maintains a uniform cutting speed, regardless of the diameter at the cutting tool.

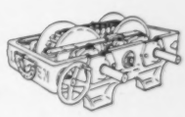


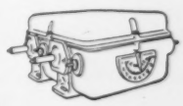
Control machine speed... a wartime production MUST

● YOUR production machines may not resemble the one illustrated above. But, with Lewellen variable speed adjustability, and positive and accurate controls over complete range, *any* of your driven machines can be operated at top efficiency under all conditions. Often what a machine can do is simply a matter of its operation at the correct speed at the right time.

Why change belts and gears when speeds can be regulated by the simple turn of a handwheel and controlled, mind you, *without stopping the machine?*

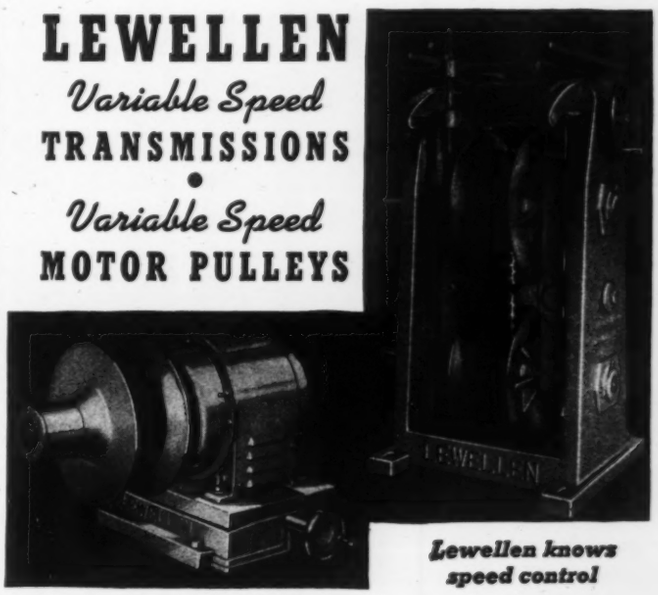
Ease your struggle for greater wartime production at lower costs. We urge you to let us help you! Call a Lewellen representative or write us. Lewellen Manufacturing Co., Columbus, Indiana.



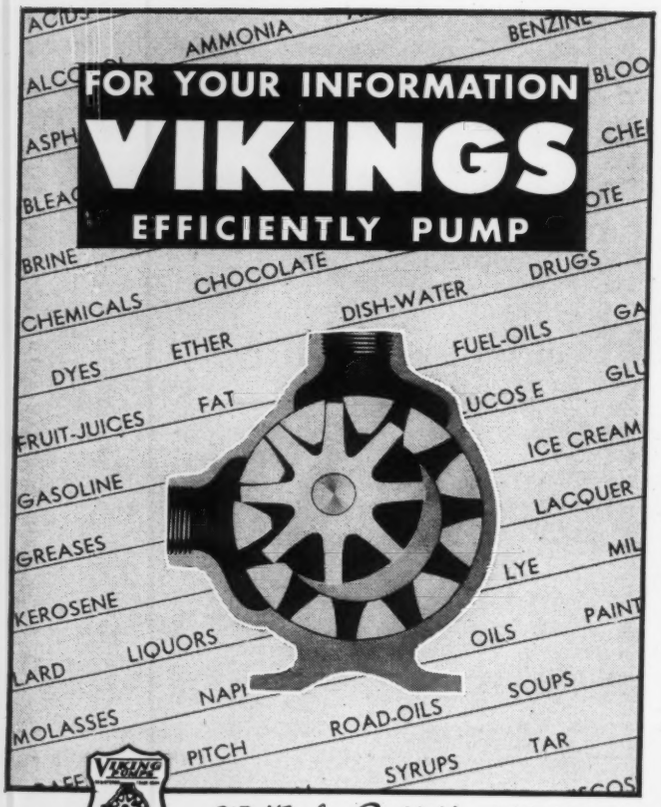


Lewellen Variable Speed Transmissions are made in open and enclosed types—vertical or horizontal—in all sizes from fractional h.p. to 40 h.p. Lewellen Variable Speed Motor Pulleys are available for all ratings from fractional to 7 h.p. Speed range, 3 to 1 for all pulley sizes. (One size has a speed range of $2\frac{3}{4}$ to 1.)

LEWELLEN *Variable Speed* TRANSMISSIONS • *Variable Speed* MOTOR PULLEYS



Lewellen knows speed control



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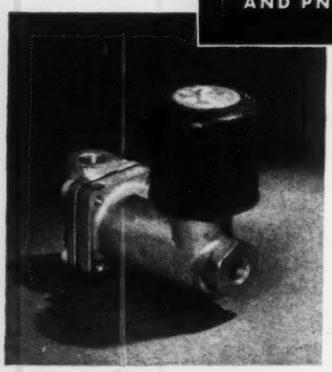
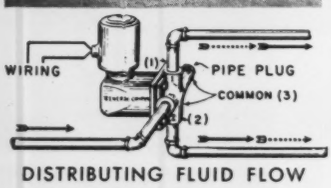
FOR FLUID DISTRIBUTION, SELECTION OF FLUID SOURCES AND PNEUMATIC PUMPING ETC.





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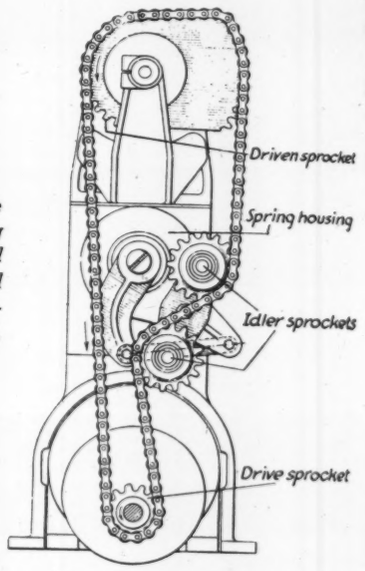
at the upper part of the machine, the irregularly shaped sprocket. As illustrated, the left side of the chain loop is the driving side. Since, of course, the chain on the driving side moves at a constant linear speed, the periphery of the driven sprocket will also move at such a constant speed, although its angular velocity will be variable.

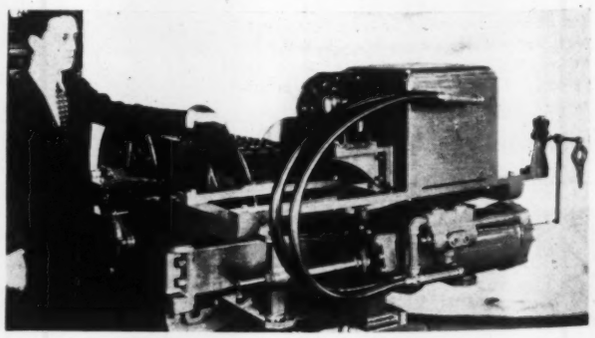
In order to accommodate the cyclically recurring slack in the idle side of the chain, a pair of idler sprockets is provided. These sprockets are mounted on a rocker arm pinned to the machine frame.

Constant surface speed for processing irregularly shaped objects is provided by replaceable, irregularly shaped, driven sprocket

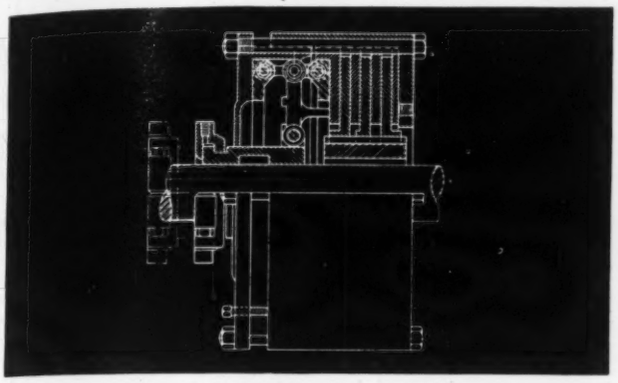


When the driven sprocket has rotated counterclockwise through an angle of approximately 90 degrees from its illustrated position, it is apparent that the idler sprockets will have also rotated about the pinned joint of their rocker arm in a counterclockwise direction, providing the necessary additional length of chain required by the eccentricity of the driven sprocket.

HYDRAULIC control provides completely automatic speed variation on the transmission shown below. Designed by Reeves Pulley Co., the unit maintains uniformly high peripheral cutting speed on a veneer cutting machine. In this way, production of the machine is increased by increasing the speed of rotation of the log being cut as its diameter decreases.



KINNEY CLUTCHES



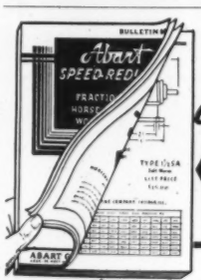
Kinney Oil Type Clutches

The Kinney Oil Type Friction Clutch—or cut-off coupling—is a fully enclosed multiple disk clutch especially adapted for direct connecting machinery to Diesel engines. Its simplicity commends it to manufacturers who desire to obtain a steady, positive picking up of the load without strain on machine parts. Its construction allows for the maximum of slippage while picking up the load without impairment of its carrying capacity when fully engaged.

The clutch comprises an outer case in which a series of two or more flat friction plates are mounted. These are locked together by pressure exerted near the outer rim by a double toggle mechanism—one of the most powerful mechanical movements known. Disks engage easily without vibration or noise—when disengaged, revolve freely without friction or loss of power.

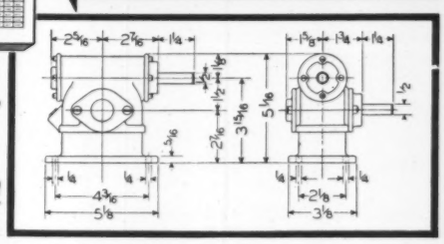
Ball bearing, bronze, or wick oiled sleeves can be furnished.

KINNEY MANUFACTURING CO.
3569 Washington St. Boston, Mass.
New York • Chicago • Dallas • Philadelphia • Los Angeles • Seattle



Just off the Press!

GET Abart BULLETIN ON FRACTIONAL H. P. SPEED REDUCERS



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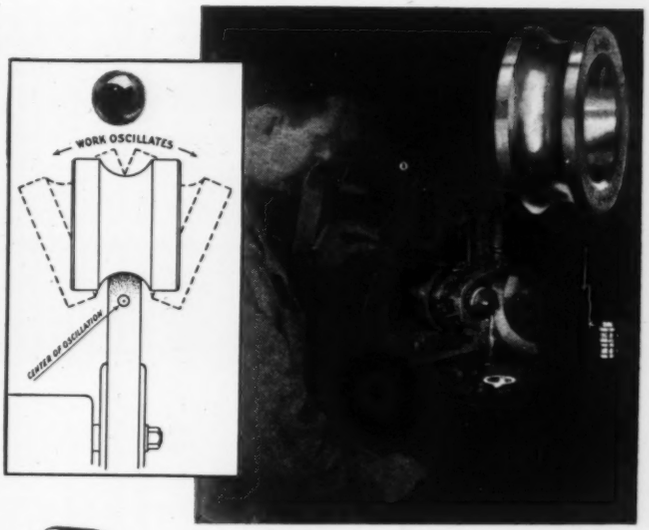
with illustrations, sectional drawings, tables, everything, on Abart Worm Units, Single Reduction type, for any and all Fractional H.P. work.

Request on your letterhead brings Bulletin Free. Shows full Abart line of horizontal and vertical applications, for normal steady intermittent, or 24 hr. service. See how you can save power, SAVE MONEY with these ruggedly-built Abart Units. Bring your gear reduction problems for heavier work to Abart also.

GEARS cut to your B P or Specifications. Highest quality. Let us quote.

Abart GEAR AND MACHINE CO.
MANUFACTURERS OF
Speed Reducers & Gears
4821 WEST 16TH ST CHICAGO ILLINOIS



Perfection IN THE GROOVE

RACEWAY GRINDING

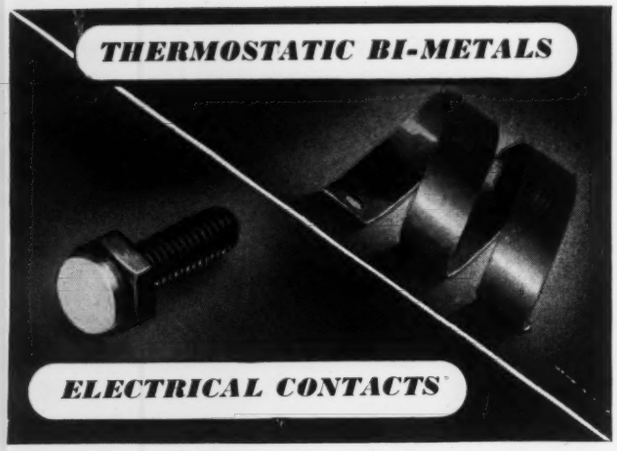
in (CJB) Bearings is done with the most modern oscillating grinders.

Steel Balls accurate in sphericity to .000025 can perform best only when the raceway in which they travel matches them in accuracy . . . note diagram.

The arc in (CJB) Ball Bearing raceways is made micromatically accurate to match the steel balls by automatic oscillating grinders.

By this method the raceway oscillates transversely across the face of the grinding wheel, as illustrated above, consequently there can be no errors in contour. That's why (CJB) Ball Bearings last longer.

CJB AHLBERG
AHLBERG BEARING COMPANY
Manufacturers of (CJB) Master Ball Bearings
3017 WEST 47TH STREET
Our West is PRECISION BEARINGS, INC. Los Angeles



We're 1A in the Draft

★ In the thick of the fight—in America's airplanes, tanks, guns and ships — Wilco thermostatic bi-metals and special electrical contacts are proving themselves unbeatable. ★ On the war production front, too, The H. A. Wilson Company offers a wide variety of specialized thermostatic bi-metals of high and low temperature types. Also a series of resistance bi-metals, (from 24-440 ohms, per sq. mil, ft.) Wilco electrical contact alloys meet war requirements . . . are available in Silver, Platinum, Gold, Tungsten, Special Alloys, Metal Powder Groups. Wilco Aeralloy is the outstanding aircraft magneto contact alloy.

WILCO

The H. A. WILSON CO.
105 CHESTNUT ST., NEWARK, N. J.
Branches: Chicago and Detroit

Gear Specialties

SPURS—SPIRALS—BEVELS—WORM GEARING
(14 to 96 D.P.)

With considerable experience and exceptional facilities for the manufacture of high precision Small Gears, our manufacturing capacity is now heavily burdened with National Defense work, and we naturally feel pardonable pride in the importance and quality of our contributions to the Program.

While this very essential work takes precedence, we are keenly conscious of our *duty* to *established* customers; their needs must command our continued earnest efforts. Under such circumstances, we hope new inquirers will understand our inability to give their wants the consideration they would ordinarily receive.

Gear Specialties
MANUFACTURERS
CHICAGO

2670 W. MEDILL AVE. Ph. HUM. 3482

Critical War Materials Already Scarce

REPORT on strategic and critical materials essential to the war effort has been prepared by government agencies. In the following tabulations are listed the scarce materials of particular interest to the design field, statements of their availability, and recommendations pertaining to conservation and substitution.

ALUMINUM: For airplanes; motor vehicles; ships. Acute shortage exists.

ANTIMONY: Storage battery plates; bearing metals; cable sheathings; lead cores for small arms ammunition. Supply may become more critical dependent upon imports.

ASBESTOS: Brake linings; gaskets; insulating material. Low-iron content grades necessary for war purposes are imported and scarce; other grades available.

BERYL ORES: Alloys for springs, bearings and nonsparking tools; ceramics; alloy with copper improves strength. Uses might suddenly become important for airplane production.

BISMUTH: Used in manufacture of fusible boiler, sprinkler and other safety plugs; low melting solders; proof casting forging dies.

BRASS: Ship construction; rotating bands; propellers and blades. Copper and zinc shortage.

BRONZE: Bars; rods; castings. Copper, zinc and tin shortages.

CADMIUM: Plating; bearings; substitute for tin in solder. Present deficiency might increase.

CHROMIUM: Alloy in steel; armor plate; rifle linings. Stock-pile adequate for short time only. Production inadequate but increasing.

COBALT: Ceramics; as a catalyst; as a drier in varnish; and in electroplating; in tool steel as a hardener.

COPPER: Motor vehicles; wire and electrical instruments. Insufficient for defense needs; conservation essential.

GRAPHITE: Lubricants; crucibles; paints. Further supply of imported grades (Ceylon and Madagascar) questionable; crucible grade must be conserved.

JEWEL BEARINGS: Precision instruments. Dependent upon imports. Domestic production inadequate. Scarcity exists.

LEAD: Cable coverings; white and red lead; ammunition; paints. Deficiency imminent.

MAGNESIUM: Scavenger and deoxidizer in casting nickel, copper, zinc and aluminum alloys; manufacture of military pyrotechnics; alloys for aircraft. Acute shortage. Additional capacity under construction.

MANGANESE: Manufacture of steel. Dependent upon imports.

MERCURY: Electrical control instruments; used for the manufacture of mercury fulminate for detonators and primers; in silvering searchlight mirrors; in antifouling paint; manufacture of felt; paravene. Dependent upon domestic production and imports from Mexico. Situation improving.

MICA: Rubber manufacture (insulation); commutator segments; armatures; airplane motor spark plugs and magnetos; radio condensers and radio

SERVING ARMY, NAVY, AIR FORCE, MERCHANT MARINE AND INDUSTRY

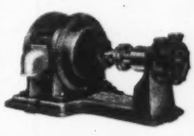
MODEL CK HIGH-PRESSURE PUMPS

In service on machine tools, engines and hydraulic mechanisms, Tuthill Model CK positive displacement, internal-gear rotary pumps are demonstrating their dependable high-pressure performance today, as never before.

TUTHILL PUMPS ARE SAVING MATERIAL, LABOR, TIME AND SPACE IN WAR-TIME PRODUCTION

MODEL CK SERIES—Compactly designed ball-bearing high-pressure pumps, obtainable in capacities from 1 to 50 g.p.m. with a pressure range up to 400 p.s.i. Foot mounting or flange mounting. Simple in construction, these efficient pumps are furnished with direct motor drives, V-belt units and integral drives.

DIRECT MOTOR DRIVES — Model CK pumps are not only precision-built, but also engineered for the job. Note the compact direct motor drive illustrated as a typical example of how Tuthill meets space limitation problems—always important, now vital.



Write for complete Tuthill Catalog describing this series and other Tuthill Pumps for production machinery and scores of war-time applications.

TUTHILL PUMPS

TUTHILL PUMP COMPANY, 941 EAST 95th ST., CHICAGO, ILLINOIS

We Grew Up With AMERICA

1942 marks Graver's 80th year in serving industrial America with steel plate equipment for many uses.

★

Just an infant in 1862, we have grown and developed with America — shared its problems and the solving of them — used each new experience as a stepping stone toward greater service to mankind and industry.

★

We are proud to have grown up with America — proud to have contributed to the building of the greatest nation on earth — and we are glad that we are continuing to contribute our utmost in helping America fight to preserve freedom.

★

In these critical times it is difficult to serve all of those whom we would like to serve, but our Government's needs must be supplied as quickly as possible. Here at Graver this will be done, and we hope that peace will soon return that we can again serve Industry with steel plate equipment as needed — and when needed.

GRAVER

STEEL STORAGE TANKS — VAPOR CONSERVATION SYSTEMS
WELDED CONSTRUCTION — STRESS RELIEVING — X-RAYING
FABRICATED STEEL AND NON-CORROSIVE PLATE — WATER SOFTENERS
FILTRATION SYSTEMS — CLARIFIERS — SEWAGE EQUIPMENT

GRAVER TANK & MFG. CO., INC.

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EAST CHICAGO, IND.
CABLE ADDRESS — GRATANK

NEW YORK
CATASAUQUA, PA

CHICAGO
TULSA

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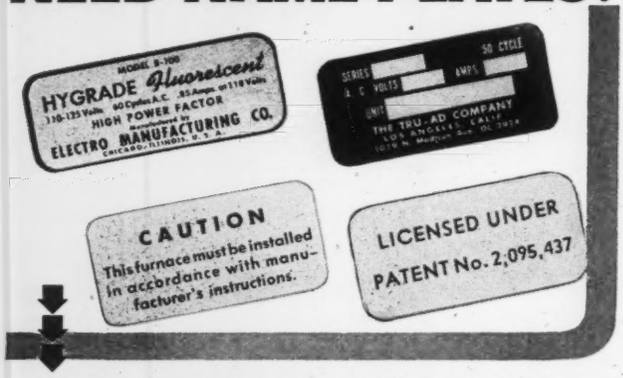
NEED NAME PLATES?



KUM KLEEN TAGS SAVE METAL AND LABOR

These amazing new stickers save vital metal and actually do a more efficient job. No drilling, no tapping—they stick permanently to any smooth surface and never pop off even under intense heat. They are applied without moistening to any smooth surface including glass and plastics—yet are easily pulled off without leaving a trace.

Already Kum-Kleen tags and stickers are at work in war industries taking the place of metal identification, instruction and patent number tags. They speed plane production as inspection, rejection and identification stickers.

» *Send now for catalog and samples, try them in your plant and office.*

Kum-Kleen LABELS

AVERY ADHESIVES, DEPT MD-4 451 E. 3RD ST., LOS ANGELES, CALIFORNIA

Keep your Machines

RUTHMAN GUSHER COOLANT PUMPS

When your coolant pumps are *not* "on the alert" your machines are slowed down . . . precious hours are wasted.

Gusher Pumps respond "quick as a wink" . . . no metal-to-metal contacts . . . not injured by chips and grit. Simple design gives you many *exclusive* advantages. Write for data.

We can make comparable speedy deliveries!

Baby Gusher

P3 Baby Gushers are available in external right or left discharge models, flange-mounted and immersed models.

THE RUTHMAN MACHINERY CO.
1811 READING ROAD, CINCINNATI, OHIO
LARGEST EXCLUSIVE BUILDERS OF COOLANT PUMPS

tubes; heaters. Dependent on imports from Africa, India and Brazil. Supply situation growing serious.

MOLYBDENUM: Production of ferroalloys and special steels. Demand increasing rapidly; increased substitute for scarce alloys.

MONEL METAL: Sheet metal, castings; shafting for pumps. A nickel-copper alloy; acute shortage.

NICKEL: Armor plate; gun tubes and recoil mechanism; ship fittings; electroplating; corrosion-resisting alloys; high-strength alloys. Acute shortage; under strict allocation; drastic conservation and substitution essential.

OPTICAL GLASS: Rangefinders; fire control equipment; cameras. Dependent upon increased production.

PIG IRON: Used in steelmaking. Inadequate production facilities.

PLATINUM GROUP METALS: Engine ignition systems; plating for searchlights; radio frequency control. Supply adequate for time being.

QUARTZ: Radio frequency control. Dependent upon imports from Brazil; conservation necessary.

RUBBER: Tires and tubes; insulating material; bearings; gas, oil and water hose. Supply critical; facilities for substitutes inadequate; more drastic conservation and substitution essential.

STEEL: Ship construction. Shortage of vital types and shapes.

STEEL SCRAP: Used in steelmaking. Supplies inadequate; scarcity growing.

SYNTHETIC RUBBERS: Neoprene; buna S; polyvinyl chloride; butyl rubber. Insufficient production capacity until 1943.

TIN: Tin plate; solder; bearing material; in making bronze. Supply almost wholly from stockpile; conservation and substitution essential.

TUNGSTEN: Tool steel; electrical filaments; bullet alloy. Sources of supply uncertain; a deficiency exists; substitution essential.

VANADIUM: Alloy steels; chemical manufacture; glass manufacture. Acute shortage; essential in tool steel. Not enough for 1942; drastic substitution needed.

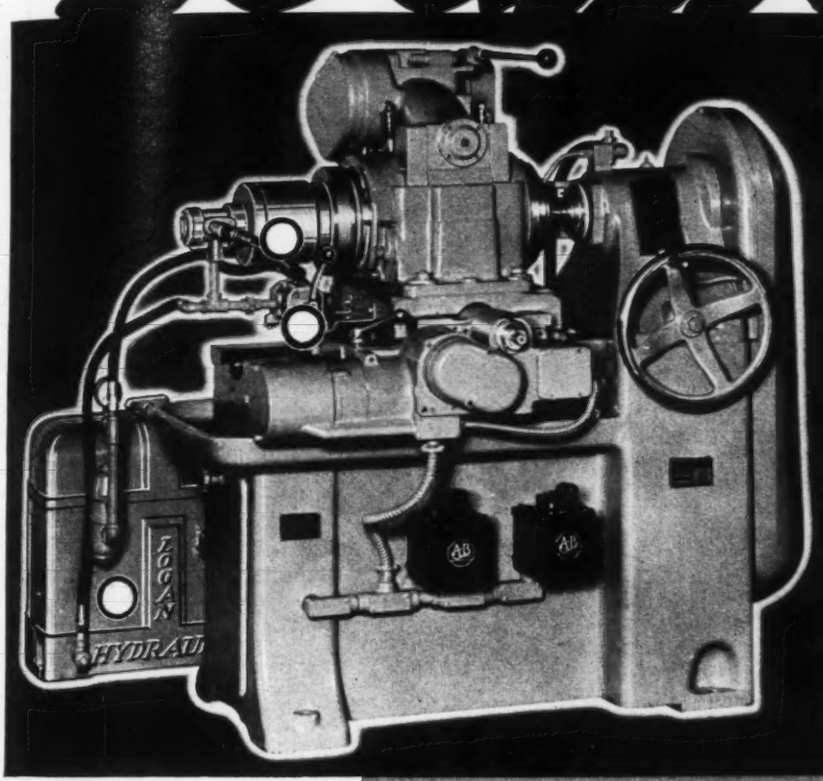
ZINC: Galvanizing; paints; bronze and brass; die castings. Scarce; must be reserved for defense needs.

They Say . . . .

"Production will soar when Americans feel the hurt of war . . . Already the nation is beginning to feel this hurt as lives are lost in the Philippines and on the high seas and that is why we already are beginning to get down to hard work . . ."—Frederic B. Heitkamp.

"I should like to talk about this job at home with some detail. It is the biggest job, bar none, that this or any other country ever tackled at any time in history. It is so huge that we can break every record we ever made and still fall short of the need. What we have done so far would be an amazing achievement if it did not have to be measured against an absolute emergency."—Donald Nelson.

"LOGAN"



HYDRAULIC EQUIPMENT

★ ★ ★ AS APPLIED TO LEES-BRADNER AUTOMATIC CHUCKING THREAD MILLER

"LOGAN" Model "HR" Hydraulic Cylinder

"LOGAN" Model 5022 Hydraulic Power Unit

"LOGAN" Model 4095 Hydraulic Control Valve

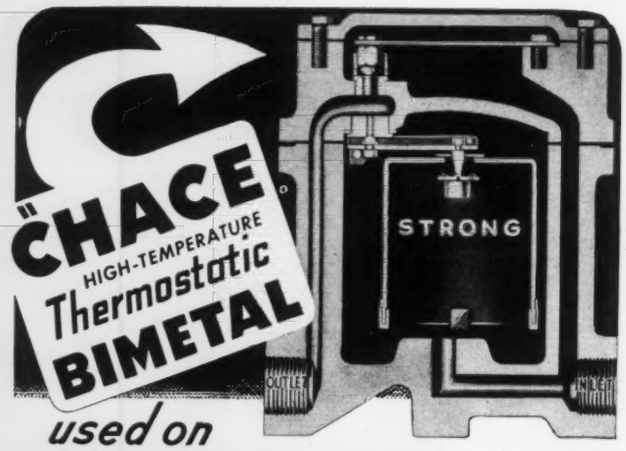
"LOGAN" Sure Flow Coolant Pump

"LOGAN" equipment consists of—(1.) A "LOGAN" Hydraulic Power Unit as an entirely independent source of fluid power supply, assuring constant pressure for the continuous and efficient operation of the "LOGAN" Hydraulic Cylinder. (2.) A "LOGAN" Rotating Hydraulic Cylinder is used to actuate a collet chuck, which holds the item to be threaded. (3.) A "LOGAN" 4095 Balanced Four Way Piston Type, Hand Operated Valve controls the action of the hydraulic cylinder. (4) Coolant is supplied by a "LOGAN" Sure Flow Pump mounted to the back of the machine. "LOGAN" Representatives and Engineers will be glad to make recommendations on your hydraulic problems.

★ **LOGANSPORT MACHINE, INCORPORATED** ★

911 PAYSON ROAD LOGANSPORT, INDIANA

Manufacturers of Air and Hydraulic Devices, Chucks, Cylinders, Valves, Presses and Accessories



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STRONG Steam TRAPS

STRONG, CARLISLE & HAMMOND CO., CLEVELAND, OHIO

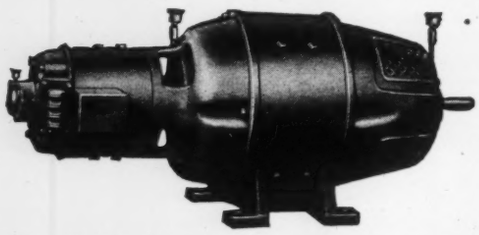
This trap provides fast two-way drainage on cookers and unit heaters. Mechanical operation of inverted bucket discharges condensate intermittently through one valve while a separate by-pass allows free passage of air and water until sufficient temperature causes the small Chace Thermostatic Bimetal strip to bend and close the second discharge valve opening. Wherever temperature is a factor, use Chace Bimetal for automatic action.

W. M. CHACE CO.
1616 Beard Avenue - - - Detroit Mich.

Janette

DEPENDABLE ELECTRICAL MACHINERY

D.C. and A.C. GENERATORS
20 to 6000 Watts D.C.—4500 v.a. A.C.



BUILT TO SERVE YOUR NEEDS

The ruggedly constructed Janette generators are used the world over because of their remarkable reliability.

Since 1909, Janette has been building electrical equipment with outstanding success. Many vitally important industrial machines that MUST NOT FAIL, depend upon Janette apparatus.

We also build motor generators and frequency changers, 25 to 60 cycles, in the same range of sizes; 20 to 6000 Watts.

OTHER PRODUCTS
ROTARY CONVERTERS • DYNAMOTORS • 1/50 to 7½ H.P.
IN D.C. and 3 phase A.C. MOTORS and
MOTORIZED SPEED REDUCERS

Janette Manufacturing Company
556-558 West Monroe Street Chicago, Ill. U.S.A.

Steel and Wood Replace Aluminum

(*Concluded from Page 78*)

proportion of the rivets needed by the aluminum structure. In the steel ship such rivets are largely replaced by spot-welding at a considerable saving in time and cost as well as material. Cost of an installed rivet is in the vicinity of 5 cents whereas the cost for a single spot-weld is only about 1/10-cent. It also is anticipated that the slight increase in weight resulting from use of steel may be mitigated by a reduction in armor plate due to the fact that steel sheets deflect bullets more effectively than aluminum.

Substitution for aluminum resulting in further weight reduction without sacrificing performance or efficiency is promised by the use of bonded plywood for the rear portion of the monocoque fuselage section. Preliminary tests on wood models indicated that at 105 per cent design load no permanent strain was noted. Bonded plywood for these tests is supplied by Berkey and Gay, furniture makers of Grand Rapids, Michigan. Fir, spruce, birch and mahogany veneers have proved most acceptable for this service. The sheets range from two-ply to seven-ply with thicknesses varying from 1/16 to 5/32-inch.

Casein Glue Solves Problem

Plywood bonding techniques present a serious problem. Synthetic resin adhesives would give excellent service but no equipment is available at present which can apply sufficient heat and pressure to set the joints. As a result, casein glue which sets at ambient temperatures and requires little pressure to afford an adequate bond seems to be the most practical solution.

Effective and co-ordinated efforts to discover adequate substitute materials have been commonplace in nondefense engineering work. The fact that such efforts now are being made in direct armament equipment is gratifying. In many parts of such equipment there can be no compromise in the specification of materials. High alloy steel, aluminum, magnesium and other critical materials are an absolute necessity. However, where substitutions can be made without sacrifice and even with some advantage they almost inevitably have favorable repercussions all along the line.

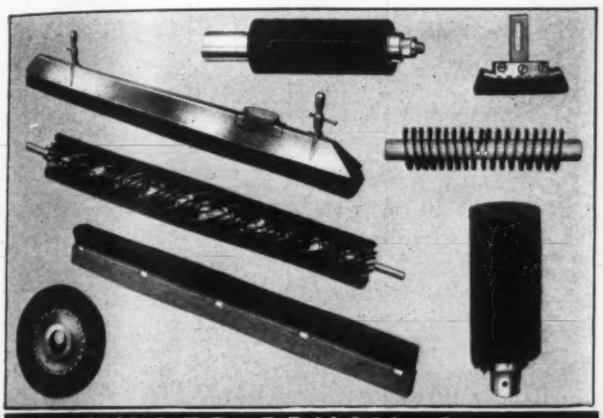
In the case of the substitution of plywood for aluminum, for example, the facilities of the entire woodworking industry are potentially regimented for all-out war work, thereby greatly increasing the country's armament production resources.

SMALL disks of Lucite, methyl methacrylate, are useful for directional signals and signs of danger spots in blackouts. They reflect light sharply from even a blackout colored flashlight.

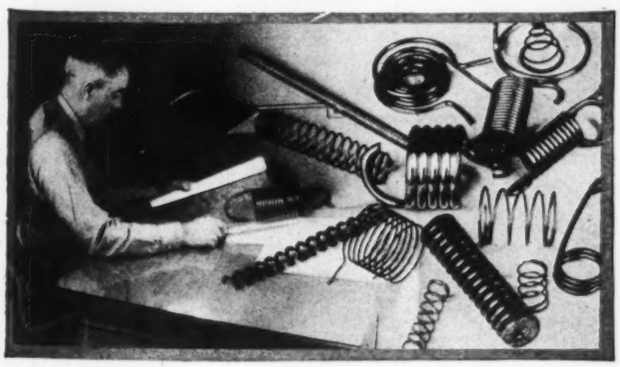
FULLERGRIPT BRUSHES
meet every machine need.
Made to Your Specifications

FULLERGRIPT made-to-order Brushes are designed for use as moving or stationary parts in machines requiring brushing operations, or for production work. Brush materials gripped in steel. Replacements with refills quickly made.

Our Engineers will work with you to fit brushes to machines in blueprint stage, or to machines in production. Send prints and specifications for quotations.



The FULLER BRUSH Company
Industrial Division, Dept. 8C
3589 MAIN STREET · HARTFORD, CONN.



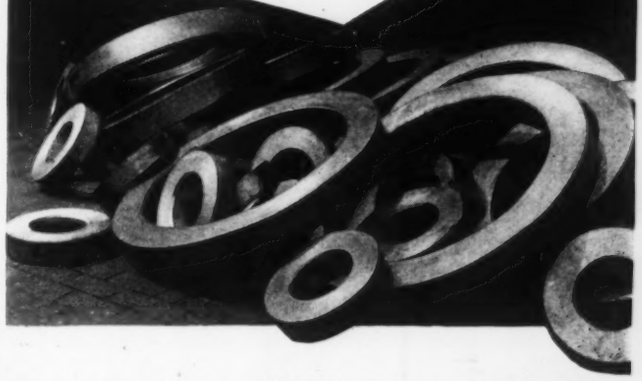
HAVE YOU A "PROBLEM CHILD"?

Springs are as necessary to the operation of war equipment as to domestic—and a thousand times more vital! If your Defense production is impeded by lack of springs that readily meet the Government's high standards, send us your specifications. We'll help you out if we possibly can. And we'll tell you promptly if we can't. Facilities for handling wire sizes from .004-.125 diameter.

PECK SPRINGS
AND SCREW MACHINE PARTS
The Peck Spring Co. 10 Wells St., Plainville, Conn.

TAYLOR FORGE

FORGED and ROLLED STEEL RINGS
-exactly as specified



Any size from 12" O.D. to 100" O.D.

YOU get exactly what you specify when you put your requirements for forged and rolled steel rings in the experienced hands of Taylor Forge.

As the world's largest manufacturer of forged steel flanges, Taylor Forge has amassed the finest equipment for forging, rolling and machining steels & alloys—exceptional facilities for heat treating — most complete and modern laboratory testing equipment.

The facilities of Taylor Forge are of particular interest to manufacturers whose product requires special heat treating and testing to insure specific characteristics.

INQUIRIES ARE INVITED

TAYLOR FORGE & PIPE WORKS
General Offices & Works: Chicago, P. O. Box 485
New York Office: 50 Church St.
Philadelphia Office: Broad Street Station Bldg.

● Other Taylor Forge Products include: "WeldELLS" and related seamless fittings for pipe welding; forged steel flanges; forged steel nozzles, necks and other outlets for pressure vessels; light walled spiral pipe; heavy walled electric-weld and forged-weld pipe; corrugated furnaces, and similar forged and rolled products.

Business and Sales Briefs

VANADIUM-ALLOYS STEEL CO., Latrobe, Pa., has appointed J. R. McCarron manager, Philadelphia office. Fred J. Herr has been transferred from the Latrobe office of the company to the Cincinnati sales office.

♦

Resignation of J. C. McQuiston as secretary-manager, and appointment of Newbold C. Goin as successor has been announced by American Gear Manufacturers association. Mr. Goin was formerly sales manager of the gearing division of the Nuttall works of Westinghouse Electric & Mfg. Co.

♦

Allegheny-Ludlum Steel Corp. has placed W. R. Kuhn in charge of its Cleveland office. Mr. Kuhn's entire business association has been with Allegheny Ludlum or its underlying companies.

♦

Formerly general manager of the Texas division of Monsanto Chemical Co., Osborne Benzanson has been elected a vice president. He was a member of the Merrimac Chemical Co., when it was taken over in 1929 by Monsanto. Early this year he was made general manager of the Texas office, which has under its jurisdiction a plant for the manufacture of raw material for synthetic rubber, and a plant for munitions.

♦

Since moving into its new building the Ruthman Machinery Co., Cincinnati, manufacturers of coolant pumps, has experienced a sizable increase in its orders. According to A. H. Ruthman, vice president, the already large output of the company's line of baby gusher pumps has increased substantially since the first of the year.

♦

H. E. Doughty, formerly district manager at the Philadelphia office of Jessop Steel Co., Washington, Pa., has been appointed assistant sales manager. He has been with the company since 1932.

♦

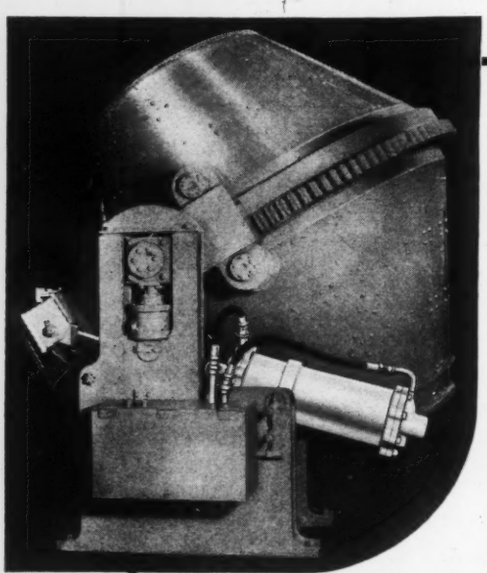
In the Chicago district Howard Broecker will represent Copperweld Steel Co., selling its Aristoloy alloy. He was previously connected with the Youngstown Sheet & Tube Co.

♦

According to an announcement made by Aircraft Screw Products Co. Inc., Long Island City, N. Y., Harkness W. Cram, sales manager of the company, has been elected vice president in charge of sales.

♦

Appointment of Albert H. Graf Jr. as sales engineer in charge of the southern territory has been announced by The Ohio Crankshaft Co., Cleveland. His headquarters will be at 819 Drewry street, Northeast, Atlanta, Ga.



New T. L. Smith 56-S Tilting Mixer equipped with NOPAK Model F Heavy Duty Air Cylinder with Trunnion Mounting to provide oscillating movement.

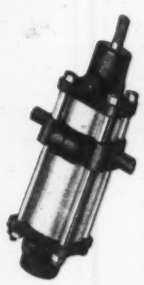
Standard NOPAK Air Cylinder Meets T. L. SMITH Design Needs . . .

Saves Valuable Time, Materials, Labor!

A rugged, long-lived, heavy duty, low-pressure air cylinder was needed to tilt the mixing drum of the new model 56-S T. L. SMITH Concrete Mixer. In addition, the specifications called for oscillating movement of the cylinder in combination with heavy side thrust.

The NOPAK Trunnion Mounted, Model F Cylinder, Heavy Duty Type, was found to meet the specifications of the basic Smith design. Only minor design changes were required. The need for new castings and fittings in the tilting mechanism was practically eliminated. Valuable time, labor and material were saved in the engineering department, foundry and on the production line.

The adaptation of standard NOPAK Valves and Cylinders to your design problems may result in similar vital savings for you. Write today for illustrated bulletins.



NOPAK Air and Hydraulic Cylinders are available with either Adjustable or Self-Regulating Cushionheads in 6 Standard Mountings, in Regular or Heavy Duty Types.

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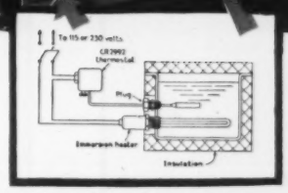
CONTINUOUS OPERATION
LOCALIZED HEATING
UNIFORM TEMPERATURE



Typical method of installing screw-in type Calrod immersion heaters, with thermostats, in process machines

TO APPLY a thermoplastic solution to paper, the Standard Process Company, Chicago, uses a machine equipped with G-E Calrod heaters, thermostatically controlled. Successful and constant operation requires that the solution be kept at 275 F.

Six heaters melt the solution. Seven maintain the storage tank at 275 F. Seven more assure constant flow by keeping the temperature 275 F in the fountain. Three more keep the rollers and blades warm.

Made Possible with Electric Heaters

It is this localized heating that assures continuous operation. No stopping the machine because the solution cooled along the line. Calrod heaters and thermostats maintain the correct temperature throughout the whole process.

Sheath temperature up to 1500 F can by obtained with Calrod heaters, providing conveniently and inexpensively the highest heat obtainable from an insulated heater.

Ratings and finishes for practically every job where metal surfaces, soft metals, or liquids need to be heated. Catalog GED-650B gives prices, and information on how you can apply Calrod heaters to your machines. For your copy, write our nearest office. *General Electric Company, Schenectady, N. Y.*

GENERAL ELECTRIC
675-20-8709

Check
THE ITEMIZED INDEX!

All drive and control developments in this issue are listed on page 5.

Every reference to materials as used in machinery can be located through page 5.

Individual design problems are classified for maximum utility, on page 5.

•

In every issue of MACHINE DESIGN all problems involving the application of parts, materials, mechanisms—in short, every detail covered by that issue is carefully *itemized.*

Constant reference is made to the Itemized Index by alert engineers as a routine part of their design procedure.

SEE PAGE 5!

Meetings and Expositions

June 8-11—

American Society of Mechanical Engineers. Semiannual meeting to be held at Hotel Statler, Cleveland. C. E. Davies, 29 West Thirty-ninth street, New York, is secretary.

June 14-20—

American Society of Mechanical Engineers. Applied Mechanics division to hold meeting at Massachusetts Institute of Technology, Cambridge, Mass. C. E. Davies, 29 West Thirty-ninth street, New York, is secretary.

June 17-19—

American Society of Mechanical Engineers. Oil and Gas Power division meeting to be held in Peoria, Ill. C. E. Davies, 29 West Thirty-ninth street, New York, is secretary.

June 20—

Eastern Photoelasticity conference. Fifteenth semiannual meeting to be held at The University club, 40 Trinity place, Boston. W. M. Murray, Massachusetts Institute of Technology, Cambridge, is chairman.

June 24—

American Society of Heating and Ventilating Engineers. Semiannual meeting to be held at Hotel St. Paul, St. Paul, Minn. A. V. Hutchinson, 51 Madison avenue, New York, is secretary.

June 22-26—

American Institute of Electrical Engineers. Summer convention to be held at the Drake hotel, Chicago. H. H. Henline, 33 West Thirty-ninth street, New York, is national secretary.

June 22-26—

American Society for Testing Materials. Annual meeting to be held at Chalfonte-Haddon hall, Atlantic City. R. E. Hess, 260 South Broad street, Philadelphia, is assistant secretary.

June 29-July 1—

American Society of Agricultural Engineers. Annual meeting to be held at Schroeder hotel, Milwaukee. Raymond Olney, Box 229, St. Joseph, Mich., is secretary.

August 23-26—

National Association of Power Engineers Inc. Annual meeting to be held at Roosevelt hotel, New Orleans. George W. Miller, 498 Winspear, Buffalo, is secretary.

September 9-11—

American Institute of Electrical Engineers. Pacific coast convention to be held at Vancouver, B. C. H. H. Henline, 33 West Thirty-ninth street, New York, is secretary.

September 16-18—

National Petroleum association. Annual meeting to be held at The Traymore hotel, Atlantic City. Mrs. M. C. Mallon, 930 Munsey building, Washington, D. C., is secretary.

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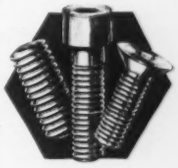

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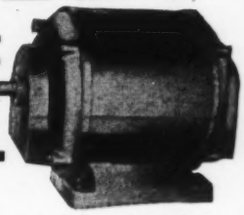

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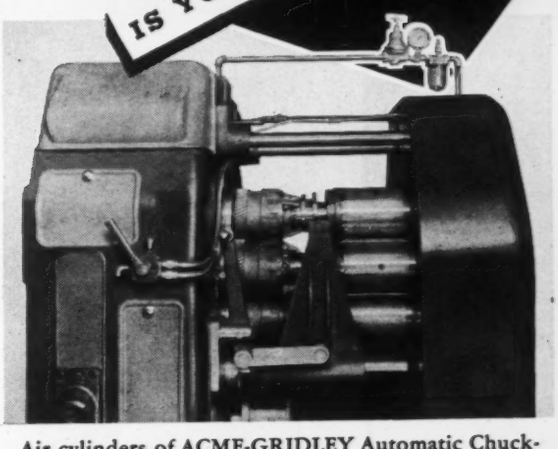

Air cylinders of ACME-GRIDLEY Automatic Chucking Machines use NORGREN Lubro-Control Units ...(1)filter air, (2)regulate pressure, (3)lubricate every working part automatically with air-borne fog of oil.

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NEW MACHINES—

And the Companies Behind Them

(For illustrations of other outstanding machinery, see Pages 84-85)

Armament

Shell washing machine, Alvey-Ferguson Co., Cincinnati.
Shell welding machine, Taylor-Hall Welding Corp., Worcester, Mass.
*Gun barrel lathe, Seneca Falls Machine Co., Seneca Falls, N. Y.
Straightening press for plane struts and gun barrels, O. C Keckley Co., Chicago.

Engraving

High-speed commercial and industrial engraving machine, New Hermes Inc., New York.
*Fuse marking machine, Jas. H. Matthews & Co., Pittsburgh.

Finishing

Piston polishing and buffing machine, Udylite Corp., Detroit.
Electric sander, Detroit Surfacing Machine Co., Detroit.
Carbide tool grinder, Standard Electrical Tool Co., Cincinnati.
Centrifugal galvanizer, Leon J. Barrett Co., Worcester, Mass.

Food

Juice dispenser, Froid Laboratories, South Grand Rapids, Mich.
Refrigerator air circulator, Reynolds Electric Co., Chicago.
Telescope can sealer, Minnesota Mining and Mfg. Co., St. Paul, Minn.

Industrial

Dust collecting system, Leiman Bros., Newark, N. J.
Weight printing scales, Toledo Scale Co., Toledo, O.
Dust collector, Edward Blake Co., Newton Centre, Mass.

*Illustrated in pictorial spread, Pages 84-85.

Materials Handling

Wire rope electric hoist, Wright Mfg. Div. of American Chain & Cable Co. Inc., York, Pa.
Heavy-duty electric hoist, Chisholm-Moore Hoist Corp., Tonawanda, N. Y.

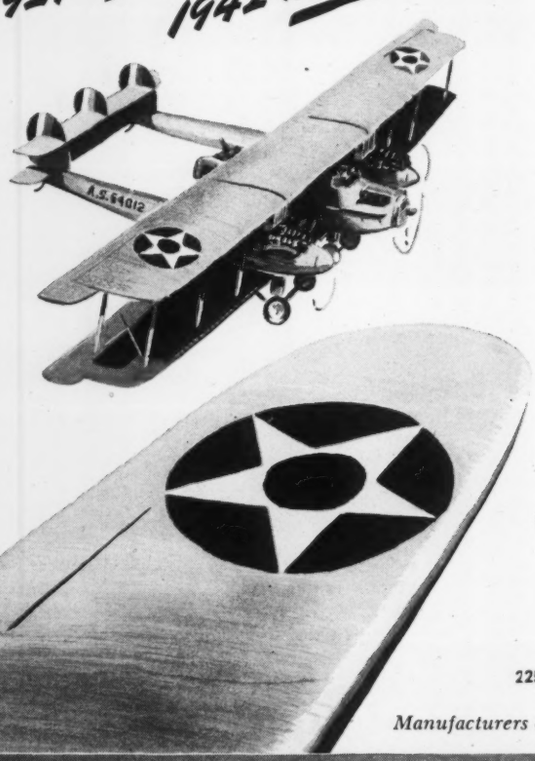
Metalworking

*Rotary surface grinder, The Taft-Pierce Mfg. Co., Woonsocket, R. I.
*Double-housing planer, Mesta Machine Co., Pittsburgh.
*Eight-spindle vertical lathe, The Bullard Co., Bridgeport, Conn.
*Thread-milling machine, Automatic Machinery Mfg. Corp., Bridgeport, Conn.
Friction saw, Kling Bros. Engineering Works, Chicago.
*Hydraulic forming and flanging press, Beatty Machine & Mfg. Co., Hammond, Ind.
Horizontal boring machine, Baush Machine Tool Co., Springfield, Mass.
Drilling machine table, Taylor Mfg. Co., Milwaukee.
High-speed automatic press, Diebel Die & Mfg. Co., Chicago.
Turret miller, Aircraft Machinery Corp., Burbank, Calif.
Punch press, Duro Mfg. Co., Los Angeles.
Metal shaper, Porter-Cable Machine Co., Syracuse, N. Y.
Ram-type turret lathe, International Machine Tool Corp., Libby Div., Indianapolis.
Turret lathe, G. M. Diehl Machine Works, Wabash, Ill.
1000-ton straightening press, Watson-Stillman Co., Roselle, N. J.
Thread milling machine, Murchey Machine & Tool Co., Detroit.
Power feed milling machine, Miller & Crowningshield, Greenfield, Mass.
Aircraft drill, U. S. Electrical Tool Co., Cincinnati.
Wet abrasive cutting machine, Andrew C. Campbell Div., American Chain & Cable Co. Inc., Bridgeport, Conn.
Abrasive wet cutting-off machine, A. P. de Sanno & Son Inc., Phoenixville, Pa.
Multiple dial feed press, Federal Press Co., Elkhart, Ind.
Milling machine, Jefferson Machine Tool Co., Cincinnati.

Plastic

Press for simultaneous loading and extrusion, Watson Stillman Co., Roselle, N. J.

1921 Good then— 1942 Better Now



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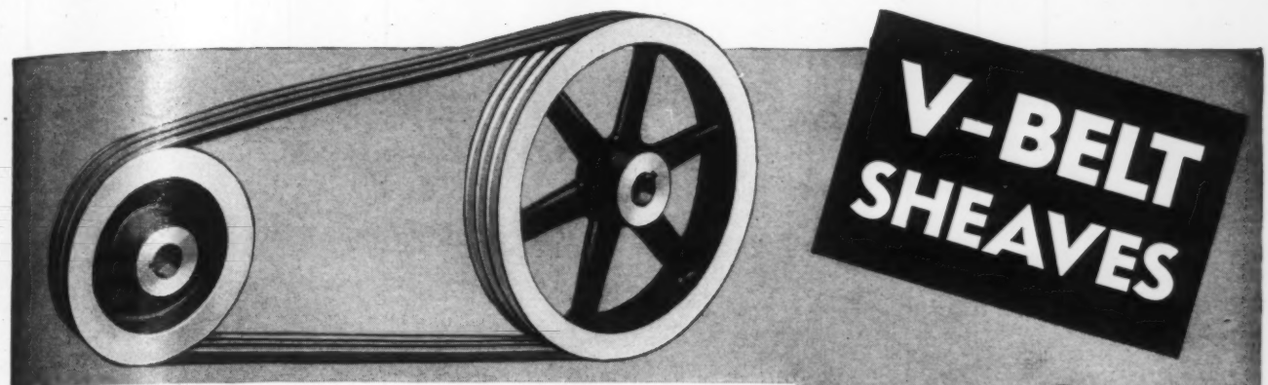

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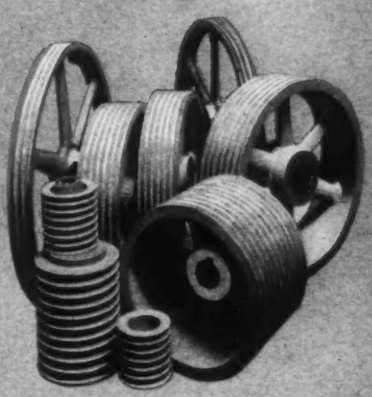

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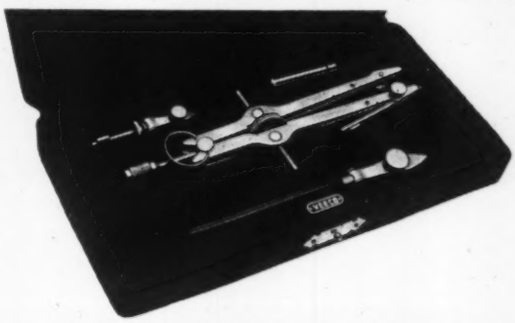

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